DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

REPORT OF THE

FOREST PRODUCTS RESEARCH BOARD

With the Report of the Director of Forest Products Research

FOR THE YEAR 1932

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REPORT OF THE FOREST PRODUCTS RESEARCH BOARD FOR THE YEAR 1932

To the Lords of the Committee of the Privy Council for Scientific and Industrial Research

MAY IT PLEASE YOUR LORDSHIPS,

WE, the Forest Products Research Board, beg leave to present our report for the year 1932.

GENERAL

1. The year under review is the sixth since the establishment of the Forests Products Research Laboratory at Princes Risborough, and has been marked by a definite advance in fundamental research into those growth characters of wood which influence its strength, permeability and other properties. Further progress has been made in an endeavour to establish the principles underlying the satisfactory machining and finishing of different kinds of timber. The chemical changes induced in wood by heating at temperatures not greatly exceeding the boiling point of water have been the subject of investigation and as a result a closer insight into the mechanism of the thermal decomposition of wood has been achieved. As the outcome of recent research into the chemistry of the decay of wood resulting from the action of the so-called " white rots," it has been shown that, contrary to earlier opinion, such fungi are capable of decomposing both carbohydrates and lignin. Experiments have been successfully carried out to devise apparatus to test the resistance of timber to abrasion. It is confidently anticipated that, following minor alterations and adjustments the machine used in the experiments will be capable of use for standard abrasion tests in the near future.

TESTS OF THE NATURAL DURABILITY OF DIFFERENT TIMBERS

2. Numerous enquiries have been received concerning the durability of well known as well as of the less common timbers, and even in connection with the former, it is not always possible to give precise information. It has therefore become necessary to determine some method of procedure by which the natural durability of a timber may be tested and the results made comparable with those obtained from other well-known species. The method adopted at the Laboratory has been to expose an equal number of specimens of heart- and sapwood to the attack of various wood-destroying fungi for a definite period, and then to determine the resistance of the timber from the weight of the specimen. The resistance is expressed as the percentage of the original weight of the timber which remains at the end of the experiment. English oak has been chosen as the species with which other timbers will in future be compared in determining their resistance to decay. Field tests are also a feature of the investigation of natural durability.

Work for the Empire Oversea

3. The interest in Empire timbers on the part of the wood-consuming professions and industries has in no way diminished and the applications for tests of, and advice upon, such timbers have again showed a marked increase. This may be attributed partly to a genuine desire on the part of consumers to utilize Empire products more extensively, and partly to the policy of Colonial Governments of developing their forest resources more intensively in response to the increasing demand for timbers of Empire origin. At the instance of the Empire Marketing Board, the Department agreed temporarily to release an experienced officer of the Laboratory, in the autumn of 1932, in order that he might be sent by that Board to Nigeria and the Gold Coast. The visit was made possible by the co-operation of the Colonial Governments concerned, and your Board has confident hopes that, as a result, a more intimate contact will be established between these regions of production and consumers in the United Kingdom. In furtherance of the policy of Colonial Governments of developing their forest resources more intensively in response to the increasing demand for Empire timbers, the Colonial Office has arranged with the Board a special course of training in utilization for selected Colonial Forest Officers, who will make a comprehensive study of the requirements of this country's markets, and the best methods of organising the development of colonial forest resources to meet those requirements.

J. C. IRVINE,
Chairman.

May, 1933.

REPORT OF THE DIRECTOR OF FOREST PRODUCTS RESEARCH FOR THE YEAR 1932

Introduction

During the year under review the progress of the work of the Forest Products Research Laboratory has been maintained. The large number of enquiries which have been received indicate that there is an increasing appreciation of the value to the timber trade and timber-using industries of the various investigations which are being carried out or have been completed at the Laboratory. It is satisfactory to be able to report that increasing interest in Empire timbers has been evident, and that the applications for tests have shown no falling off in numbers.

At the end of the year 1932 there were 154 persons in employment at the Laboratory including : Scientific and Technical Staff, 49 ; Laboratory assistants, boys and girls, 21 ; Office Staff, 15 ; Foreman and Industrial Staff, 69. A detailed list of the Scientific and Technical Staff is given in Appendix I.

1. MISCELLANEOUS

Collection of Wood Specimens

The development of the Laboratory's reference collection of wood specimens during the period under review has been satisfactory. At the end of 1932, the collection comprised a total of 5,179 named specimens, representing 2,007 named species of 791 genera, an increase of 910 specimens during the year. For purposes of record, it is of interest to give the actual number of additions, but it is emphasised that their value for research purposes very largely depends upon their being in the first place correctly named, and in the second place, truly representative of the particular species concerned. If the identity of a timber specimen is not established by its correlation with adequate herbarium material collected from the same tree, the possibilities of error are considerable. The acquisition of reliably named specimens of certain timbers has repeatedly revealed serious mistakes in the naming of old specimens which were presumed to be correct. The importance of selecting every specimen from the trunk of a mature tree is not always realized by collectors. Samples taken from branch-wood or young trees are not altogether useless for scientific work, but they are inadequate when it is desired to assess their potential economic value as timber. It is satisfactory to record that a large proportion of the specimens added to the collection during the past year have emanated from reliable sources and many of them are correlated with herbarium sheets which are filed for reference in the Herbarium of the Imperial Forestry Institute, Oxford, or of the Forest Department concerned.

The preparation of a number of sets of home-grown timber specimens for distribution under exchange arrangements has enabled the Laboratory to reciprocate the gifts of numerous collections of timber specimens which have been received from Forest Departments and Research Institutions at home and abroad. Specimens of Empire timbers for distribution and exchange have also been prepared from the consignments of timber investigated under the auspices of the Empire Timbers Committee.

Co-operation with the Imperial Forestry Institute

For reasons of economy it has been found necessary to curtail the work carried out, on repayment, by the Imperial Forestry Institute at Oxford. Under the revised arrangement, which provides for the maintenance of one full-time and one part-time investigator, with the necessary laboratory assistance, research in wood structure has been continued on woods of the families Sterculiaceæ and Leguminosæ, the description of a number of African timbers and general methods of identification. The first of a new series entitled " Forest Trees and Timbers of the British Empire," dealing with a number of tropical African species, has been issued by the Institute and material for the second of the series has been prepared.

Fifth International Entomological Congress

The Fifth Congress of Entomology was held in Paris from 16th to 23rd July, 1932. The Laboratory was represented at the Congress by the Officer in Charge, Entomology Section. The meetings were arranged in sections, of which those dealing with applied entomology and forest entomology have a direct bearing upon the work of the Laboratory. A paper entitled " Some Aspects of the *Lyctus* problem in Great Britain " was read before the section of forest entomology.

Empire Timbers Day

To further the interest in Home-grown and Empire timbers and to bring certain species to the notice of users, a special display was organised at the Laboratory on 12th July, 1932. Invitations were issued to a large number of representatives of the timber-using trades and professions and approximately two-hundred-and-fifty of the recipients visited the Laboratory in response. Arrangements had been made for all Sections to participate by having work on Empire timbers in evidence during the day. The result was most gratifying both from the view of establishing closer contact between the Laboratory and users of these timbers, and from the numerous enquiries since received which can be directly attributed to the exhibit.

Panelling in the Board Room of the Laboratory

During the year 1932 the walls of the Board Room have been panelled in accordance with a design prepared by H.M. Office of Works. This was very desirable in order to improve the acoustic properties of the room, and in carrying out the work it was deemed advisable to use a number of Empire timbers of home and oversea origin in order to demonstrate their possibilities for decorative purposes. The design called for the use of ten large panels above and thirty small ones below the dado rail. Elm, mainly Dutch and Wych, was used for framing the panels, for the architrave and other mouldings and for the window linings. This was carefully seasoned and reconditioned before being installed, in an endeavour, which promises to be successful, to prevent twisting, warping or other movement in the wood after erection.

The large panels, five of each, are of :—

Indian laurel (*Terminalia tomentosa* Wight and Arn.), India ; and
Queensland walnut (*Endiandra Palmerstonii* C. T. White), Australia.

The panels below the dado rail are of :—

Bombay blackwood (*Dalbergia latifolia* Roxb.), India ;
Kokko (*Albizzia Lebbek* Benth.), India ;
Australian blackwood (*Acacia melanoxylon* R.Br.), Australia ;
Walnut (*Juglans regia* L.), Great Britain ;
Brown oak (*Quercus* sp. probably *Q. Robur* L.), Great Britain ;
Indian silver greywood (*Terminalia bialata* Wall.), India ;
Iroko (*Chlorophora excelsa* Benth. and Hook. f.), Nigeria ;
Figured elm (*Ulmus glabra* Hudson), Great Britain ;
Figured teak (*Tectona grandis* L.f.), Burma ;
Andaman padauk (*Pterocarpus dalbergioides* Roxb.), Andamans ;
Munyama (*Khaya anthotheca*), Uganda ;
Canadian birch (*Betula lutea* Michaux.), Canada ;
Cherry (*Prunus Avium* L.), Great Britain ;
Bird's-eye maple (*Acer saccharum* Marsh.), Canada ;
Douglas fir (*Pseudotsuga taxifolia* Brit.), British Columbia ;
Western hemlock (*Tsuga heterophylla* Sarg.), British Columbia ;
Pedunculate oak (*Quercus Robur* L.), Great Britain ;
Honduras mahogany (*Swietenia macrophylla* King), British Honduras ;
Benin mohogany (*Khaya* sp.), Nigeria ;
East Indian satinwood (*Chloroxylon Swietenia* C. DC.), Ceylon ;
Yew (*Taxus baccata* L.), Great Britain ;
Burr alder (*Alnus* sp.), Great Britain ;
African walnut (*Lovoa Klainena* Pierre ex Sprague), Nigeria ;
Brown ash (*Fraxinus excelsior* L.), Great Britain ;
Crabwood (*Carapa guianensis* Aubl.), British Guiana ;
Figured African-mahogany (Identity in doubt, probably *Entandrophragma* sp.), Nigeria ; and
Sapeli (*Entandrophragma* sp.), Nigeria.

The doors are of Figured walnut, *Juglans regia* L. (Great Britain) and the panels over the doors are of quartered Silky oak, *Cardwellia sublimis* F. Muell. (Australia).

For pecuniary reasons it would have been impossible to carry out this work, had it not been for the generosity of a number of people who presented nearly all the panels. These were the gifts of the Hon. F. P. Burden, Agent-General for British Columbia ; J. R. P. Gent, Esq., late Deputy Director of Forests, Nigeria ; Messrs. Wm. Mallinson & Sons, Ltd. ; Messrs. James Latham, Ltd. ; Messrs. W. W. Howard Bros. & Co., Ltd. ; Messrs. William Marshall & Son ; Messrs. James Webster & Brother, Ltd., and Messrs. James P. Fraser & Co. Considerable reductions in the price of materials were obtained from the vendors in the few cases where it was necessary to make purchases.

II.—THE PROGRAMME OF RESEARCH

(United Kingdom Division)

Standard Descriptions of Timbers

Accurate information in the form of standard descriptions of timbers is necessary for identification and comparison and to enable the Laboratory to deal with every-day problems affecting the properties and uses of commercial timbers. This work is based

on the study of specimens in the Laboratory collection combined with the published work of other investigators. Descriptions are prepared whenever occasion arises for the examination of a species and these are drawn up in such a way that they can be amended when further material becomes available for examination. The preparation of standard descriptions of timbers is intimately bound up with the question of variation, which may be studied by two different methods. The examination of a large number of specimens selected at random from as wide a range as possible will eventually furnish the desired information, but a more practical means to the same end is to establish, if possible, the laws governing the normal variation in different types of wood structure. The examination of the various timbers that have passed through the Laboratory in recent years has furnished an accumulation of data which are being subjected to statistical analysis. It is anticipated that this will facilitate future work by indicating the variability of different anatomical features and hence their value for diagnostic purposes, and also the number of observations necessary in order to obtain a reasonably accurate picture of the typical wood structure of a species.

The Classification of Commercial Timbers

The cosmopolitan character of the British timber market demands a working knowledge of a large variety of woods from all parts of the world. Thus, supplies of softwood are drawn from sources ranging from Northern Europe to Vladivostok in the east and Vancouver Island in the west. Oak used for furniture and cabinet making has an even wider range of distribution, while almost every timber-exporting country in the tropics contributes a "mahogany" to the English market. Most research on the natural classification of trees and timbers has been done on a geographical rather than a botanical basis, and there is much to be done in collating the work of investigators in different parts of the world. Woods of the family Dipterocarpaceæ, which includes Andaman gurjun, keruing from the Malay Peninsula and Borneo, and apitong and bagac from the Philippine Islands, have assumed considerable importance in recent years, so much so that it has been found expedient to make a special study of the commercial species of this group, so far as they are known, combining the researches of other investigators with a study of the material in the Laboratory collection. Similar investigations on the softwoods and mahoganies of commerce have been carried on as opportunity has permitted.

The Structure amd Properties of Wood

One of the main considerations underlying the Laboratory's investigations of home-grown timbers is the effect of local ecological conditions and sylvicultural treatment on the technical properties of timber. The anatomical structure of wood is probably one of the most important factors in determining its physical properties and a close correlation also exists between structure and conditions of growth. The examination of structure therefore forms a natural link between sylviculture and utilization in enabling the results of mechanical and physical tests to be interpreted in terms of the growth characteristics of the trees. The detailed investigation of the anatomical structure of a single species with reference to its conditions of growth on the one hand and its technical properties on the other, necessarily involves a large amount of work on a wide selection of material, so that for many years to come only a limited number of species can be dealt with in that way. Elsewhere in this report reference is made to current investigations on ash and British-grown Sitka spruce.

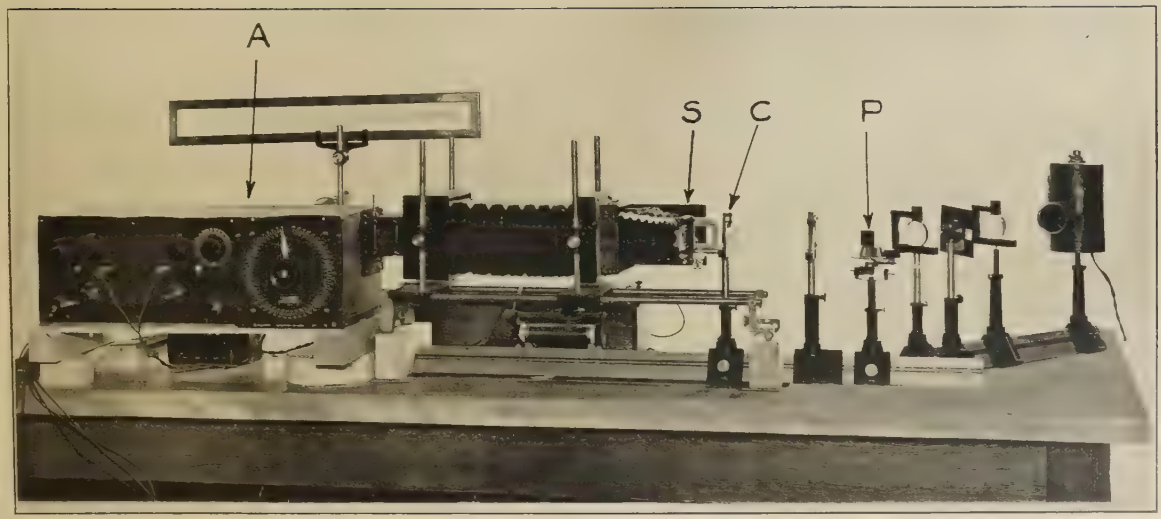


FIG. 1.—*Apparatus for the determination of Cell Space Ratio.*

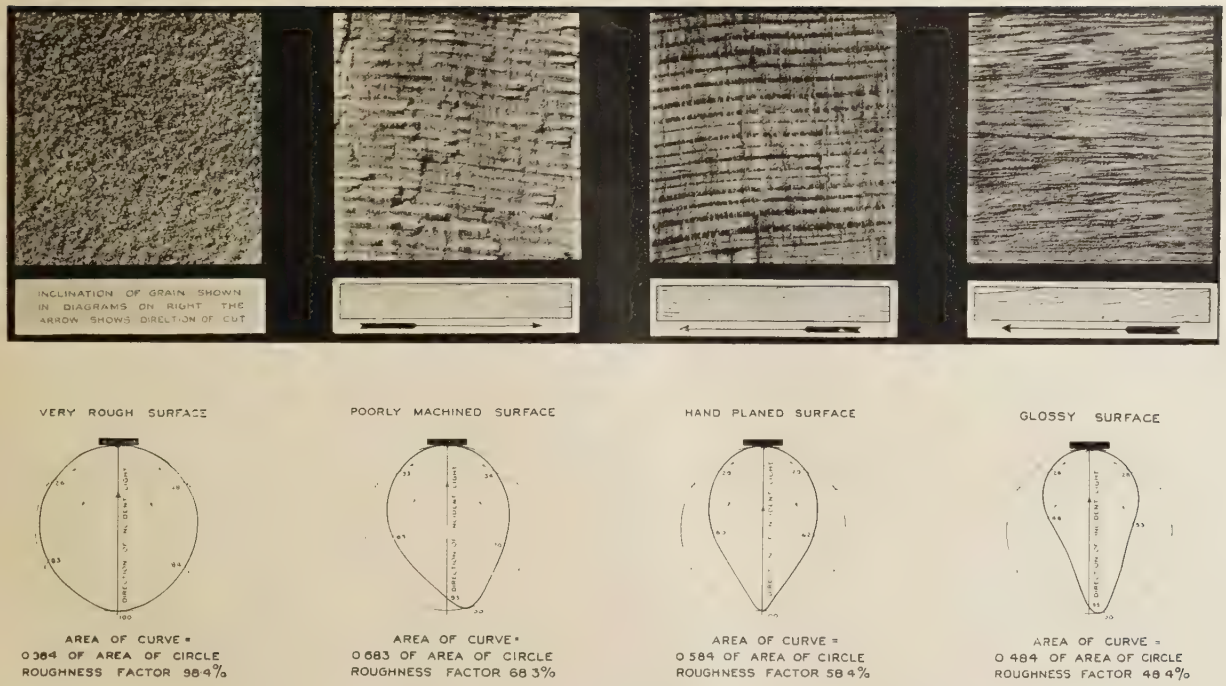

INCLINATION OF GRAIN SHOWN IN DIAGRAMS ON RIGHT. THE ARROW SHOWS DIRECTION OF CUT.
VERY ROUGH SURFACE
AREA OF CURVE =
0.364 OF AREA OF CIRCLE
ROUGHNESS FACTOR 98.4%
POORLY MACHINED SURFACE
AREA OF CURVE =
0.683 OF AREA OF CIRCLE
ROUGHNESS FACTOR 68.3%
HAND PLANED SURFACE
AREA OF CURVE =
0.584 OF AREA OF CIRCLE
ROUGHNESS FACTOR 58.4%
GLOSSY SURFACE
AREA OF CURVE =
0.484 OF AREA OF CIRCLE
ROUGHNESS FACTOR 48.4%

FIG. 2.—*Optical Measurement of Smoothness. Polar curves of scattering of light from a wood surface in a plane parallel to the grain.*

Determination of Cell Space Ratio

The use of the photo-electric photometer for the measurement of the percentage of void space per unit area of cross section of wood was explained in the report for 1931. The method consists of measuring the change in the quantity of light entering a photo-electric cell from a source of measured intensity due to interposing a stained microsection of wood in the path of the beam. Since no stain is perfectly opaque, the light is transmitted not only through the cell spaces but also to some extent through the stained wall of the section. This involves a correction to the measured transmission of the section before the true cell space ratio can be determined. During the current year the method has been further studied and progress has been made, but the chief difficulty still lies in the correction necessary for the light transmitted by the cell wall since it is found that the colour of the dye used may be slightly changed on being absorbed by the wood. Since the sensitivity of the photo-cell varies considerably for the different colours of the spectrum it follows that a slight change in colour of the stain may cause large changes in the measurements of the photo-cell.

Experiments are being made on the changes in colour of the dye due to absorption by the wood. Fig. 1 shows a photograph of the apparatus used, in which the illuminating beam is passed through a prism P to form a spectrum at the point C from which any narrow range of spectrum colours may be chosen to illuminate the microsection placed at S. The photometer is seen on the left (A).

Work on this method is being continued since, if it should prove successful, it would be possible to measure the Cell Space Ratio rapidly and would provide a useful aid in the study of the effects of different treatments—e.g., of the re-conditioning of wood—on the volume of the cell wall as distinct from the volume of the wood in bulk, or of the correlation between structure and mechanical strength.

Problems associated with the Machining Qualities of Timber

Work on this subject by the Section of Timber Physics during 1932 has been confined to attempts to measure the smoothness of the machined surface of wood by optical and thermal methods.

The optical method described in the last report, has been further developed and a fair degree of differentiation between surfaces is now possible as will be seen from Fig. 2, which shows photographs of four surfaces magnified about $3\frac{1}{2}$ times, with below, the polar graphs obtained by measuring the quantity of light scattered at all angles to the surface. It is of interest to note that the polar curves are not necessarily symmetrical about the normal to the wood surface. This asymmetry is due partly to the grain of the wood not lying absolutely parallel to the surface, Fig. 2 (iv) so that when the wood is cut across smoothly the backs of the severed cells are exposed and act as small inclined facets which give a preferential reflection slightly off the normal. Another cause of the asymmetry is seen in Fig. 2 (ii) where bad planing has caused tearing out of the surface, again leaving inclined surfaces which reflect the light off the normal. (Compare with Fig. 2 (iii) for a matched specimen well planed which gives a practically symmetrical curve). The grain in specimens (ii) and (iii) is more nearly parallel to the cut surface than in (iv). The curve for sandpaper is symmetrical and gives almost complete scattering of the incident light.

These curves for the wood sections were each taken with the grain horizontal, i.e., parallel to the plane in which the scattering is measured. If, however, the curve is

taken with the grain vertical, almost complete scattering is obtained for *any* surface. The scattering in this plane is due to the exposed hollows of the cut cells acting as small concave mirrors of very short focal length (see Fig. 3). Parallel light falling on such mirrors will, after passing through an approximate focus very close to the surface, be scattered over an angle of almost 180°. This wide angle scattering, naturally masks the scattering due to the cut surface of the cell wall. At present the surface is illuminated by a parallel beam of light falling normally on it, but it is possible that illumination at other angles might yield more sensitive differentiation between surfaces. Experiments on these lines are being considered. Other work dealing with the measurement of the quality of finish by mechanical methods is described on page 36.

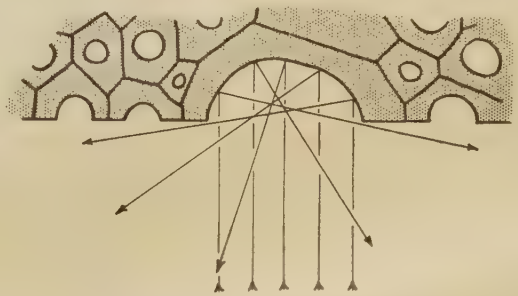


FIG. 3.—*Scattering of Light from Cell Walls in a Plane perpendicular to the direction of the Grain.*

Some preliminary work has also been done on the possible relation between the thermal conductivity of a surface and its smoothness, corresponding to the " cold " feel of a smooth surface if touched by the hand compared to a rough one. A heated plate which has been allowed to reach a state of equilibrium with its surroundings will, if suddenly placed on a solid surface, lose heat to that surface at a rate which is dependent on the conductivity of the interface—the smoother the surface the better the conduction of heat across it. This loss of heat was measured by taking the temperature gradient in the plate very close to the surface of contact. Time was not available to make an exhaustive investigation though there were indications of the method being workable. It is hoped to resume work on this line if opportunity offers.

In the last annual report, mention was made of the report,[1] then in preparation, on the working qualities of timber. This has now been published.

[1] BARKAS, W. W., van REST, E. D., and WILSON, W. E. The Principles of Woodworking: A Survey of Present Knowledge on this Subject. *Forest Products Research Bulletin* No. 13. H.M. Stationery Office, 1932. Price 2*s.* 6*d.* net.

Thermal Diffusivity

Work on the measurement of this property has been continued and the apparatus improved so that it is now possible to carry out experiments under better control of temperature. From the results obtained so far on oak, the coefficient of diffusivity does not appear to vary over a moderate range of temperatures, but it may be that variations in the coefficient occur which are too small to be revealed by the method. Certain refinements in the apparatus are being made in order to study this point.

Retention of Water by Wood

The colloidal nature of the cell wall substance becomes increasingly evident as the investigation of its properties proceeds. Thus, a useful avenue of approach to its physical study is indicated in considering the material as, at any rate in part, a hydrophilic swelling gel similar to wool, cotton and many other natural fibres which differ from the amorphous gels in that their molecular structure consists of long chains of oriented molecules, grouped into micellæ, the long axis of the molecule lying approximately parallel to the micella length. This explains for instance the fact that wood will swell in water in the radial and tangential directions while longitudinally little expansion occurs—the water molecules attach themselves to the side linkages of the carbohydrate chains, causing an increase in the overall dimensions of the transverse section. The actual amount of water taken up varies of course with the chemical constituents of the complicated structure we call "wood" and to some extent also with the previous physical treatment of the material, which may modify the micella grouping.

The last year has seen the start of an investigation into the mode of retention of water by wood. Differences of opinion exist as to whether the water below the fibre saturation point is held, as suggested above, by adsorption—a loose chemical bond between the gel and the water—or whether it is held by the capillary action of surface tension of the water in the micro-structure of the cell wall. This point was tested out on Sitka spruce flour by a method considered to be decisive in differentiating between the two theories, a short outline of which has been published.[1]

The preliminary results go to show that for wood completely saturated in water, a quantity of water equal to some 20 per cent. of the dry weight of the wood is held by adsorption and not by capillary retention—an amount not far short of the moisture content at the fibre saturation point.

The true value of the fibre saturation point for a particlar wood is not definitely known since the figures obtained by different methods show considerable variation. This is due partly to the fact that at the fibre saturation point slight changes in the hygrometric condition produce very large changes in the moisture content, and partly because the methods of measurement (e.g., the change in the rate of shrinkage or in the mechanical strength with change in moisture content of a saturated sample) involve properties which may not be quantitatively connected with the fibre saturation point. On the other hand, the quantity of water adsorbed by the wood, if not equal to the quantity held at fibre saturation point, is almost certainly a definite function of that quantity so that if these preliminary experiments on moisture retention are upheld by the more refined work which it is hoped to undertake, it seems probable that a more definite value of the fibre saturation point may be obtainable in this way.

[1] Barkas, W. W. Retention of Moisture by Wood. *Nature*, 1932, **130**, 699.

The Shrinkage of Wood

The study of wood shrinkage has been continued, and various further aspects of the subject investigated. The contention that old timber is more stable than newly seasoned timber is being studied. Sample pieces of old timber have been obtained from old buildings and matched samples of new timber have been prepared. The matched pairs are being subjected to changing atmospheric conditions and any dimensional changes noted. At the moment the indication appears to be that there are only slight, if any, differences in the amount of movement of old and new wood.

Further experiments on the "cupping" of flat-sawn timber have been made and agreement has been obtained in many cases between the actual and the predicted distortion. Cupping results from differences between the shrinkages in the directions tangential and at right angles to the annual rings, and from purely geometrical considerations the ultimate curve will be of the form $r \cos a\theta = b$, where a and b are simple functions of the radial and tangential shrinkages. In practice the cupping during drying is frequently affected by internal and external stresses. The results obtained from some very carefully dried samples of ash and beech are illustrated in Fig. 4. It should be noted that the ordinates of these curves are shown on the scale of 10 to 1.

The measurement of movements in green beech consequent on temperature changes has been undertaken and has shown that for an increase in temperature there is expansion in the tangential grain direction, but contraction in the longitudinal and radial directions. This is discussed further at a later stage under the heading of "Reconditioning" (see page 12).

The Relations between the Moisture Content of Wood and the Surrounding Hygrometric Conditions

The investigation of the equilibrium values of the moisture content in wood corresponding to different temperature and humidity conditions of the surrounding air has been continued, and further figures have been obtained.

As an extension of a previous investigation small samples of all species of timber received at the Laboratory are now prepared and kept under various conditions (e.g., in an office, bedroom, unheated store, etc.) and weighed at regular intervals. Thus the moisture content change throughout the year can be determined, and the requisite degree of seasoning for any specific purpose arrived at. So far the tests on twelve different species have been completed while those on many others are in hand.

In collaboration with a firm of contractors the Laboratory is studying the behaviour of wood samples placed in new or partially constructed buildings. The tests are not yet complete, but the results already indicate that high moisture contents obtain for some time. It will therefore clearly be undesirable in many cases to install fine timberwork in a new building before the shell has dried to some extent. In this connection, a temporary heating system may be beneficial in rendering the building fit for the timberwork sooner than would otherwise be the case.

The local effect of radiators in panelled rooms is a point of importance where shrinkage of the timber is undesirable. Matched pairs of oak, mahogany and deal panels were located over a hidden wall radiator, and on a wall remote from a radiator. The changes in moisture content were observed from time to time. The panels hung over the radiator fluctuated over a range of 5 per cent. moisture content, while in the case of the other panels the range was only 3 per cent., the difference corresponding to an additional shrinkage or expansion of about ·06-in. per foot width.

Kiln-seasoning Experiments

The experimental kilns of the Laboratory have been in constant use and a considerable amount of information has been collected as a result. Kiln experiments on a large scale have been made on ash, beech, elm, Lowland fir, (*Abies grandis*, Lindl.), hornbeam, Maritime pine, European spruce, oak, Scots pine and Sitka spruce.

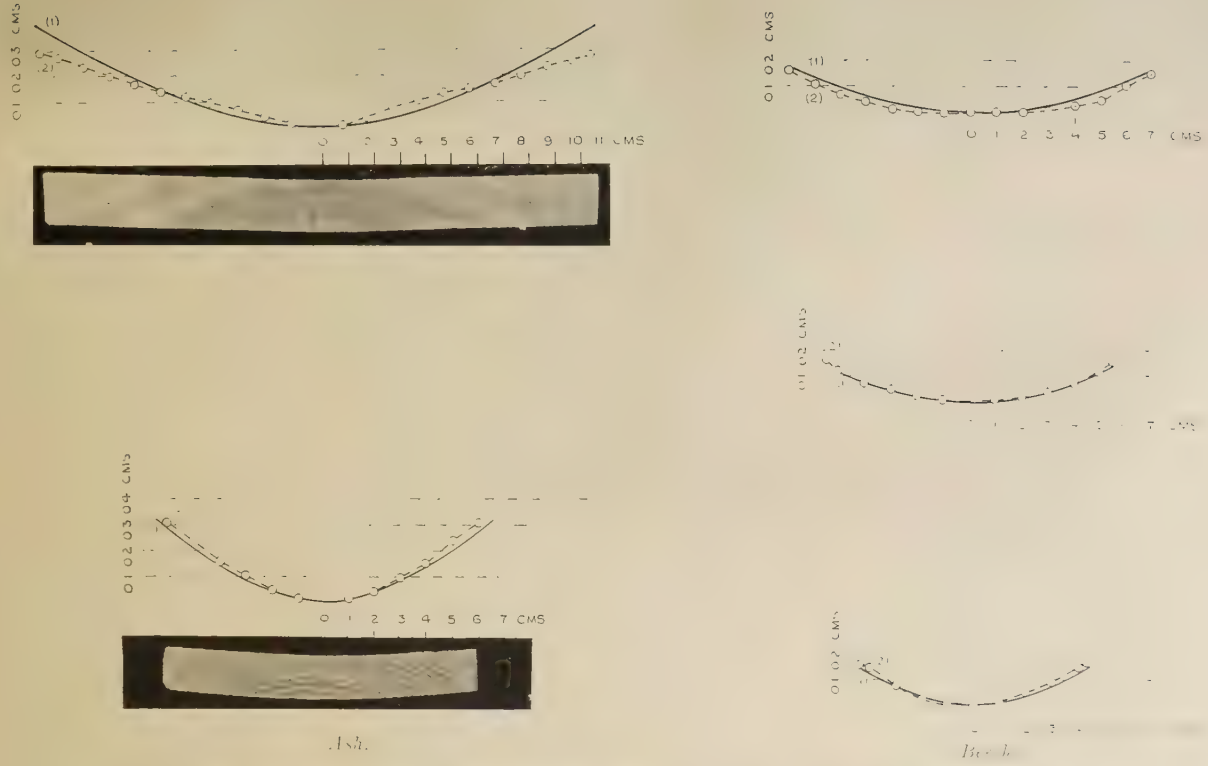


FIG. 4.—*The Cupping of Timber. Full line shows predicted Cupping; Dotted line shows actual Cupping.*

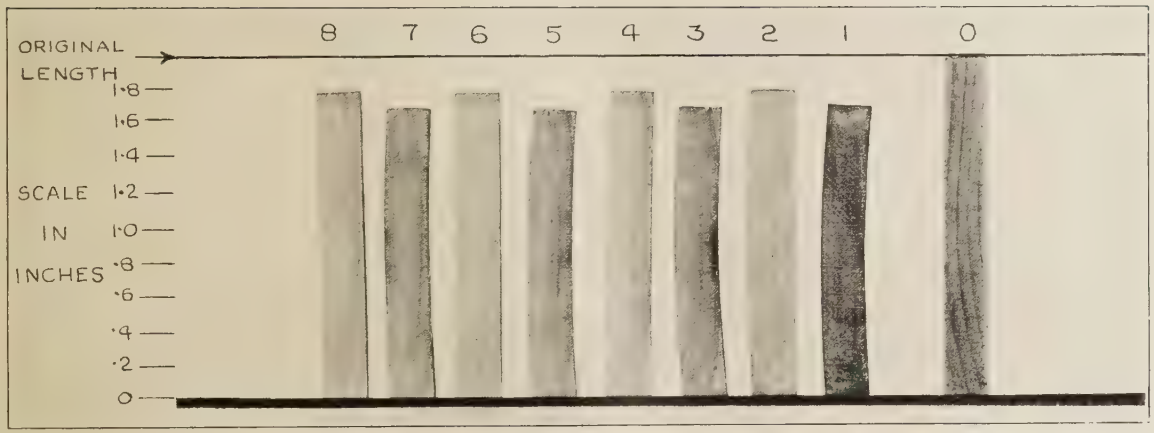


FIG. 5.—*The Effect of Drying Treatments on the Shrinkage of Timber.*

0 Size of original sample.
1, 3, 5 and 7 samples dried at high temperatures and high humidities.
2, 4, 6 and 8 samples dried at low temperatures and low humidities.
All the specimens except 0 were dried to the same percentage of moisture

The Maritime pine seasoned very well indeed, while the European spruce seasoned almost as well, though appearing somewhat sensitive to low humidities. The Sitka spruce had a tendency to rib, and both it and the Lowland fir suffered from splitting of the knots.

In connection with the cost of artificial drying the consumption of steam is obviously of major importance. The Laboratory has been investigating this aspect, and as a result certain factors, having an important bearing on steam consumption, have come to light. Tests carried out in the fan kilns have shown that a considerable proportion of the steam supplied to a kiln is used in the steam spray and is dependent to a large extent upon the air and vapour interchange in and out of the kiln. This interchange, which is in some instances necessary as a means of getting rid of the moisture extracted from the wood and affording accurate control of the humidity conditions, can easily become excessive and so cause a serious waste of steam. In most kilns the walls and doors will act to a certain extent as condensers and extract moisture from the circulating air by means of condensation. In addition, there is usually some unavoidable leakage in and out of the kiln through the joints in the doors, etc., and these act as an uncontrolled air interchange which helps in extracting the surplus moisture from the air. To obtain the maximum efficiency therefore the kiln should have good, well-insulated doors with air-tight joints and the air interchange should be carefully controlled and maintained at a minimum just sufficient to afford an accurate means of humidity control. Otherwise the loss of heat may be of serious economic importance.

The uniformity of air flow through a pile of timber in a kiln, especially when the incoming air has a high velocity, is often greatly dependent upon the contour of the faces where the air enters and leaves the pile. A convenient way of testing the air speed and circulation between various layers in a pile is by means of smoke. The velocity of the air passing between any particular layers can be obtained fairly accurately by timing a puff of smoke across the width of the pile. Tests have shown that the mean velocity of the air between the layers is roughly equal to five-eighths of the maximum smoke velocity so measured. It has been shown by such tests that in the case of piles with irregular contours, the air flow underneath any layer which projects unduly over the main incoming air stream, is usually greatly in excess of the air flow between the layers immediately above. In some cases also, the air may actually be sucked out of the spaces between layers immediately above such projections. For this reason, it has been found good practice to arrange for the contour of the face of the pile to be unbroken at the sample rows, by placing a plank or portion of a plank at the extreme edge of the row. This plank is not withdrawable and can form part of the normal contour of the face of the pile. While it is not always desirable, in view of the ultimate use of the seasoned product, to edge the timbers after conversion and before piling in the kiln, where such a process is practicable the benefit will be felt in the more uniform air circulation through the pile, and consequently more even and rapid drying. When unedged timber is piled in the kiln every reasonable attempt should be made to secure an even and unbroken surface on the pile face at which the air enters. This can often be secured by a suitable selection of the boards or planks used in building up this face of the pile.

Combined Air- and Kiln-seasoning

The new project which aims at studying a combination of air- and kiln-drying, has been put in hand, and has already shown that oak and beech seasoned by this method have the same order of degrade as results from kiln-drying from the green, or by air-

seasoning alone. Oak and beech planking (2-in. thick), if air-dried to about 30 to 40 per cent. moisture content, can be further dried in a kiln to 12 per cent. moisture content in about half the time required to dry direct from the green. Three to four months' air-seasoning should be sufficient to reduce the moisture content to 30 to 40 per cent. in the case of 2-in. oak plank, and two to three months in the case of beech.

Mechanical testing of the following species has been carried out on material seasoned by the combined process :—

Species	*From*
Beech	Berkhamsted, Herts.
Oak	Dockey Wood, Ashridge, Herts.-Bucks. border
Hornbeam	Thorndon Park, Essex
Beech	Ashridge Park, Herts.-Bucks. border.

Re-conditioning

The study of the effect of high temperature steaming on seasoned timber has been continued and the experiments, which aimed at a better understanding of the process, have been confined chiefly to ash and beech. A series of tests were carried out on small matched samples of ash and beech, dried to various moisture contents, with a view to determining the particular moisture content at which the maximum effect of re-conditioning or expansion would take place. Curves were drawn showing the measured increase in dimensions which occurred at any given moisture content as based upon the initial measurements when green, and it appeared that the maximum increase for the ash occurred when it had previously been dried to a moisture content of about 18 per cent. and for the beech to a moisture content of about 10 per cent. Further tests were made on beech specimens to determine the influence of the method of drying and consequent shrinkage upon the re-conditioning properties of a piece of wood. The results obtained were of considerable interest as they showed that the specimens of beech, when dried at high temperatures and humidities, shrank considerably more than those dried at low temperatures and humidities, see Fig. 5. It was found that the greater the shrinkage in drying the greater the recovery during re-conditioning. From these results it would appear that the shrinkage of wood may be affected by the method of drying and that, as a result of a subsequent steaming treatment, the wood tends to assume some fixed dimension as determined by the moisture content and general structure. The difficulties encountered in measuring the thermal expansion of green timber were overcome by using a roller type of extensometer, recording movements by means of a pointer and multiplying device. The tests so far have dealt with green beech and it has been shown that the wood, when heated, expanded in the tangential direction only, but that a contraction took place in both the radial and longitudinal directions. The volume of the piece, however, was seen to increase and this increase was found to be permanent, and the timber did not return to its original size when cooled. Tests were made over a long period when it was seen that although a large movement took place within a short time of heating the wood to any fixed temperature, a slight creep or continued movement took place over a period of two to three days.

The effect on the mechanical porperties of timber subjected to re-conditioning has been investigated. It is satisfactory to note that in all cases these tests have shown that the mechanical properties have been maintained at or about normal, corresponding

to the resultant moisture content. The consignments that have been tested, after re-conditioning following the kiln-seasoning process, are given below :—

Species	*From*
Dutch elm	Wheatfield, Oxon.
Wych elm	Needwood, Staffs.-Derby border
Ash	Ryston, Norfolk
Ash	Stockenhall, Rutland-Lincs. border.

Extensions to Kiln Plant

In last year's report mention was made of a steam-jet kiln which had been put into operation. This kiln was designed to fill the gap between the slow and simple natural draught kiln and the fast but relatively complicated fan kiln. In order to compare the rate of drying produced in the steam-jet kiln with that in the natural draught type, matched loads of timber were piled in each kiln and dried. The drying times for the two kilns were six and eight days respectively. Fig. 6 shows the average drying curves, for the two kilns. The daily steam consumption was about the same in each case.

A fourth model experimental kiln has been built at the Laboratory and has been working satisfactorily for the greater part of the year.

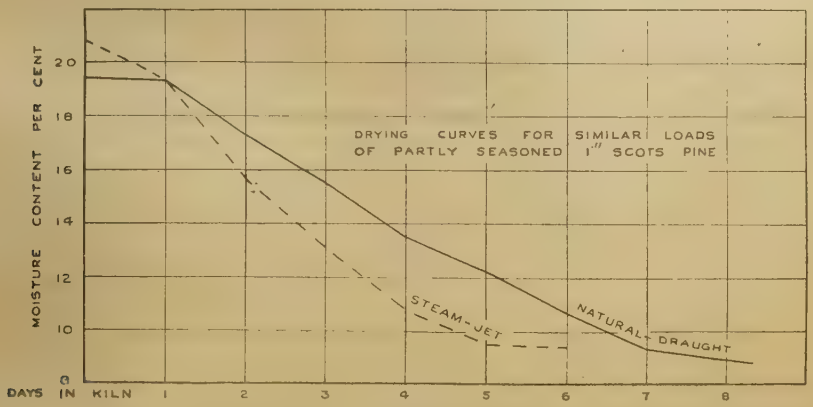


FIG. 6.—*Comparative Tests of Steam-Jet and Natural-Draught Kilns.*

Air-seasoning

A systematic investigation into various factors affecting the air-seasoning of timber was mentioned as having been started, in the report for 1931. While the tests are not yet complete many interesting points have already been determined. Air-seasoning piles of softwood 6-ft. wide have dried from the green condition to 20 per cent. moisture content in one to two months in the case of boards of 1-in. thickness, and three months in the case of 2-in. planking.

With the hardwoods (oak for instance), it was found that the green 1-in. boarding dried to 25 per cent. moisture content between May and October, 1931 : the 2-in. timber

dried to 35 per cent. in the same period. Practically no drying took place during the following winter, but it was resumed in the spring and summer, and by September, 1932, the 1-in. oak had dried to 19 per cent. and the 2-in. to 22 per cent. Had it been practicable to erect the seasoning piles in January or February instead of in May, it is possible that by October, 1931, even the 2-in. stock would have dried to 25 per cent, and the 1-in. material would certainly have seasoned to 20 per cent. It would appear that including a winter period, 2-in. hardwoods can be air-seasoned satisfactorily in eighteen months. Fig. 7 depicts the drying curves for 1-in. oak piled with different thicknesses of piling stick. It was clearly shown that the ½-in. sticks retard the drying to a very great extent, but there seems little object in increasing the thickness of the sticks above 1-in. Reducing the distance between adjacent piles from 4-ft. to 18-in. produced no apparent diminution in the drying rate, but rain was still blown into the piles

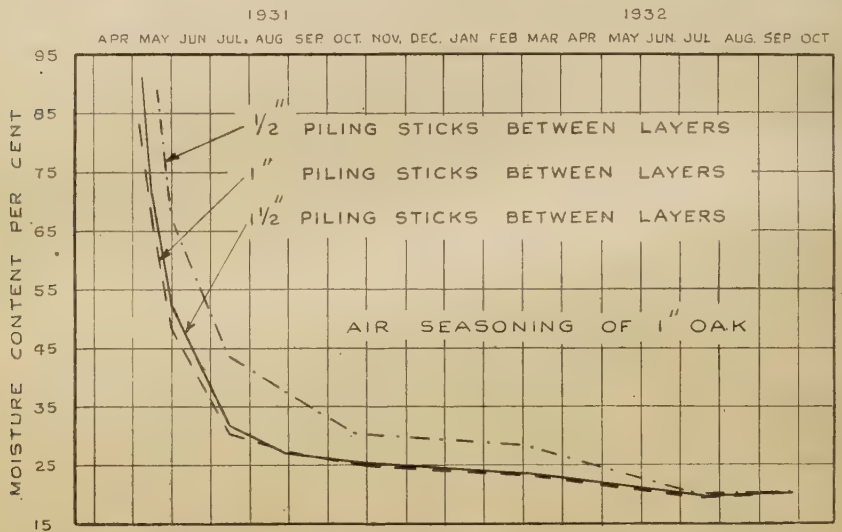


FIG. 7.—*Effect of different thicknesses of Piling Sticks on the drying rate of Timber.*

between the layers. Conflicting evidence was obtained as to the relative advantages of the laying of boards edge to edge or with spaces between. It is proposed to conduct further experiments on the optimum economic spacing between timber piles in a yard, and the new scheme will include the seasoning of softwoods in sleeper sizes.

The timber piles erected in connection with the study of combined air- and kiln-seasoning have also provided information on the air-seasoning qualities of oak, beech and hornbeam.

Steam Bending

Steam-bending investigations have been continued throughout the year, the tests being confined to three well-known bending timbers, namely—beech, ash and oak. The influence of such variables as moisture content, growth features and conversion methods were investigated and the general bending technique greatly improved. A

study was also begun of the best methods of drying and setting bends to shape, and the influence of shrinkage on the finished article received special attention. It was clearly demonstrated from the tests that success in bending depended to a large extent upon an accurate control of the end-pressures and the corresponding longitudinal movements of the wood fibres. As a result of this work the bending equipment is being modified considerably so that in the future the pressures exerted in the bending strap and the actual bending moments may be regulated and pressures recorded with more precision.

With the object of establishing a method by which the bending qualities of timber may be systematically assessed. work has been commenced on an investigation of the relation between the bending properties of the wood and the stress strain relationships in compression and tension after steaming. Preliminary tests have been carried out to determine the most suitable size and form of test piece and to provide the necessary information on which to base the design of instruments for the measurement of strain. The work is proceeding. Preliminary experiments have also been carried out to explore the relationship between the rate of drying and the rate of loss of internal compressive stress ; i.e., on the " setting " of the timber after bending. Equipment is now being designed to enable this relationship to be determined under different conditions of temperature and humidity, with the object of evaluating optimum setting schedules.

A preliminary series of observations has been carried out on the microscopic structure of beech before and after steam-bending treatment. The first stages in the deformation of a steamed and bent specimen lie within the limit of proportionality and are reversible as shown by the tendency of a specimen to resume its original shape immediately the restraining forces are removed. Beyond this limit, the fibres on the compression side of the specimen undergo a permanent deformation due to the development of minute planes of slipping in the cell walls, followed by actual failure and buckling of the fibres on a microscopic scale. By microscopic examination of sections and macerated fibres under plane-polarized light, compression stresses set up in the fibre walls can be detected before visible failure in the specimen as a whole takes place, and this method has been used to examine the degree of stress existing in different parts of a bend. Further experimental work is in hand to investigate the changes which take place in the cell walls of wood held under restraint, that is, in a condition comparable to that of a bend during the drying and setting process.

Influence of Kiln-seasoning upon Mechanical Properties of Timber

In continuation of the programme of tests to determine the influence of kiln-seasoning on the mechanical properties of home-grown timbers, investigations were carried out on material representing twenty-two kiln runs as listed in the following table :—

Species	*From*
Oak	Bedgebury, Kent
Oak	Salcey, Bucks.-Northants. border
Oak	Walcot, Montgomery-Salop border
Ash	Ryston, Norfolk
Ash	Stockenhall, Rutland-Lincs. border
Scots pine	Weasenham, Norfolk
European spruce ..	Stourton, Wilts.-Somerset border

Species	*From*
European spruce	Stanhope, Durham
Beech	Mapledurham, Oxon.-Berks. border
Sweet chestnut	Redding's Nurseries, Forest of Dean, Glos.-Monmouth border
Maritime pine	Stoboro' Heath, S. Dorset
Alder	Temple Guiting, Glos., North-East Cotswolds
Yew	Longleat, Wilts.-Somerset border
Wild Service tree	Shabbington Wood, Thame, Oxon.-Bucks. border
Lowland fir	Leighton Hall, Welshpool, Montgomery-Salop border
Norway spruce	Banchory, Aberdeen
Sitka spruce	Leighton Hall, Montgomery-Salop border
Sitka spruce	Banchory, Kincardineshire-Aberdeen border.

The procedure followed in previous years was adhered to. Related to each kiln run matched material was tested green as received and air-seasoned to approximately 12 per cent. moisture content. The kiln-seasoned material in each case was tested as soon as released from the seasoning investigation.

An important point emerging from the past year's work is the effect of kiln-seasoning on the mechanical properties of oak which indicates the great difficulty encountered in kiln-seasoning this timber. When the series of three kiln runs on this timber was completed and the results of the mechanical tests examined, it was found that Kiln-run No. 2, the longest of the series lasting 108 days, produced material in which the deterioration in mechanical properties although slight was nevertheless marked. The timber from Kiln-run No. 1, which lasted 96 days, had mechanical properties of a lower order than those of the timber in Kiln-run No. 2, while the effect was still more pronounced in the case of Kiln-run No. 3, which lasted 75 days.

The fact which appears from this consideration of the investigations is that the kiln-seasoning of oak direct from the green is not an economical process, especially when relatively high mechanical properties are desired.

Of the other species which were kiln-seasoned during the past year, none has been investigated sufficiently thoroughly as yet to permit of a similar definite analysis to that given for oak, but, from the results that are available, it would appear that although some timbers require slow seasoning in the kiln to prevent collapse and consequent serious deterioration in their mechanical properties, it is, however, possible, by selecting a suitable schedule for drying, to kiln-season most of our home-grown timbers directly from the green and, at the same time, preserve, or even, perhaps, increase the mechanical properties as compared with what they would be if air-seasoned. This is particularly true of our home-grown elm, which is liable to collapse if too quickly dried, but which may, if kept in the kiln for upwards of ten weeks under suitable conditions of moisture and temperature, be brought to the desired moisture content with increased mechanical properties. The tendency in elm, though, is towards increased hardness, which although desirable in some situations must be carefully considered if the material is to be worked to any great extent either by hand or by machine after kiln-seasoning.

Mechanical and Physical Properties of Timber

The mechanical testing of timbers has been pushed forward actively during the past year and the number of tests carried out was about 25,000 mechanical tests, in

addition to which some 30,700 physical tests and other determinations have been recorded. The increase in the output from the testing laboratory has been due largely to increased work for the Empire. On the other hand, there has been a slight decrease in the number of tests carried out on home-grown timbers and this decrease will be still more marked in the future as the information relating to the characteristics of home-grown timbers becomes more complete. There has also been an increase in the number of tests of a fundamental character. Furthermore, there has been a very marked increase in testing required by commercial firms relating to the strength requirements in timber for special uses.

The home-grown timbers investigated during the year are listed below : —

TESTED GREEN

Species	*From*
Oak	Longleat, Wilts.
Sycamore	Penrhyn Park, Carnarvon.
Hornbeam	Thorndon Park, Essex.

TESTED AIR-DRY

Silver fir	Longleat, Wilts.
Douglas fir (2 consignments)	Longleat, Wilts.
European spruce	Owston, Leicester.
Sitka spruce	Durris, Kincardine.
Beech	Brocklesby, Lincs.
Beech	Mapledurham, Oxon.
Oak	Longleat, Wilts.
Willow (Cricket bat)	Ryston, Norfolk.
Willow (Crack)	Ryston, Norfolk.

The Conditioning Chamber

The new conditioning chamber has been functioning during the year and the expectations entertained as to its value in shortening the time to obtain air-dried material as compared with trusting to uncontrolled conditions of the atmosphere were fully realized. Very satisfactory results have already been achieved through its use. It is now part of the routine procedure in the seasoning of timber preparatory to mechanical testing in the air-dry condition to pass it into this conditioning chamber after its moisture content has fallen below 20 per cent. The air-dry material from several consignments is placed in the chamber at one time and the whole of the material is brought down gradually and steadily to the required moisture content of 12 per cent. In this process it has been found advantageous to condition the timber to an average moisture content slightly below 12 per cent. and then to allow it, while still remaining in the chamber, to take up a slight amount of moisture in the outside fibres. This process accomplishes a more even distribution of moisture throughout the cross-section of each test piece and overcomes the difficulty of the moisture being somewhat higher at the centre than near the surface.

Testing of Timber in Structural Sizes

Tests on full-sized joists of home-grown Scots pine have continued and these major tests have been accompanied by a number of tests on small clear specimens cut from

the same material as the joist and serving as controls. The requisite number of physical tests relating to structure, specific gravity and moisture content have also been carried out on this material. A supplementary consignment of Baltic redwood of "Clear" grade was obtained in order to complete the data relating to the properties of this timber free from defects. A further consignment of home-grown Scots pine has been obtained from North Wales.

Analysis of Results of Mechanical Tests

The coefficient of variation (standard deviation expressed as percentage of mean) has been determined for all strength properties of green timber tested under Project 1[1] The corresponding coefficients for air-dry material are in process of calculation and, to make the results comparable, variations in strength due to changes in moisture content are being eliminated by adjustment of all results to a uniform moisture content of 12 per cent. This involves the pre-determination of the moisture-strength correction factor and although this operation necessarily slows down the work somewhat, the value of the computed quantities in application will be greatly increased.

Correlation coefficients between maximum crushing strength parallel to the grain, and specific gravity have been determined for all the material, both green and air-dry (12 per cent.), tested under Project 1[1], up to date.

The softwoods, on the whole, show somewhat better correlation in the green state than the hardwoods, but in both hardwoods and softwoods there is, rather surprisingly, a marked increase in the coefficient for air-dry material—this increase being relatively greater for hardwoods than for softwoods. The degree of variation in strength properties and the relationship between strength and specific gravity are being investigated in more detail for individual timbers and the results of such investigations will appear in the detailed reports on specific timbers.

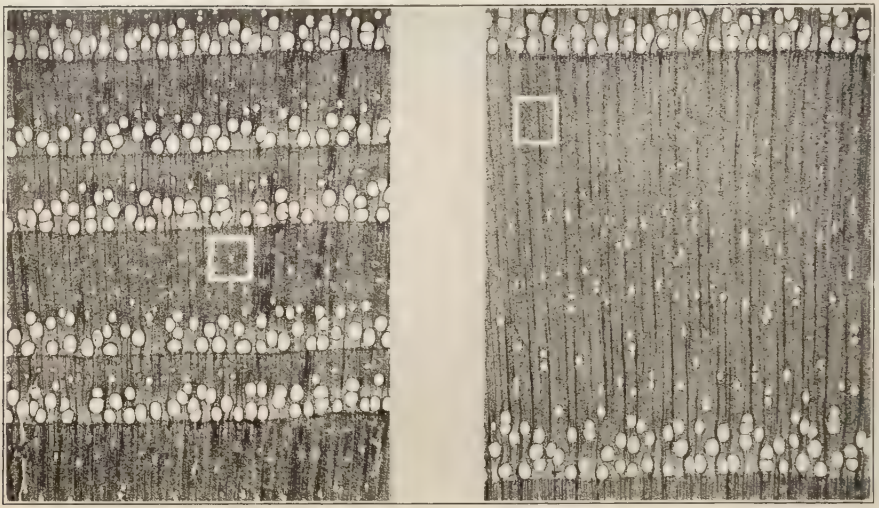
[1] CHAPLIN, C. J. Mechanical and Physical Properties of Timber. Tests of Small Clear Specimens. *Forest Products Research Project* No. 1. H.M. Stationery Office, 1928. Price 2*s.* 0*d.* net.

Committee on the Mechanical Testing of Timbers

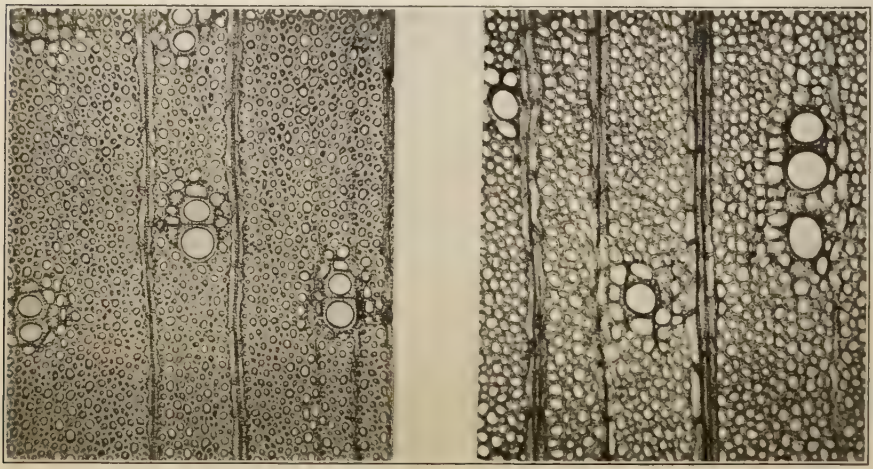
Investigations on behalf of the Committee on the Mechanical Testing of Timbers have been pushed forward and considerable progress has been made relating to the analysis of the tests on small, clear specimens of timber. Particular attention has been given to investigating the improvements on the shear test and tests on timber in tension parallel to grain. This latter test has lately been developed in co-operation with the Officers of the Royal Aircraft Establishment. The test has now been extended to include investigations on the elastic property in this direction through modification of the test piece to allow for the attachment of an extensometer. A method of shaping the specimens by machine has been developed. The tests have been quite satisfactory and the method may be readily applied to further tests of the strength in tension parallel to grain.

Deterioration in Strength of Timber due to Fungal Decay

The investigation suggested in last year's report to determine the effect of staining fungi on the strength of wood has been initiated and tests covering various periods of inoculation with each of two kinds of sap-staining fungi are proceeding. The sap-staining fungi chosen for the investigation were *Ceratostomella caerulea* and *C. cana* and



A. *Transverse Sections* × 10. B.



A. *Transverse Sections* × 100. B.

FIG. 8. *Transverse Sections of English Ash* (Fraxinus excelsior) *showing, from a single consignment, the structure of* (*A*) *the strongest specimen—maximum crushing strength parallel to grain* (*green*) = 5,300 *lb./sq. inch; and* (*B*) *the weakest specimen—maximum crushing strength parallel to grain* (*green*) = 2,270 *lb./sq. inch. The areas marked in the upper photographs are shown below at a higher magnification to illustrate the differences in the thickness of the fibre walls.*

with these the sapwood of Scots pine was inoculated. Tests of static bending on small rectanglar test pieces and in compression parallel to the grain on bobbin-shaped test pieces are in progress, the specimens being prepared from clear sapwood in the green condition obtained from a consignment of Scots pine. The technique employed and the methods of test were similar to those in investigations previously reported[1].

When the investigation was first planned, it was determined to test the inoculated specimens at intervals of one month. As the tests proceeded, however, it became evident that these one-month periods were too short, as no progress in the attack of the fungus could be detected until several months had elapsed. This slow advance in the attack of the fungus is attributed to the very moist condition of the samples, which did not allow the staining fungi to penetrate readily. The periods between the tests were then lengthened and the tests are still continuing over these longer incubation periods.

[1] Cartwright, K. St. G., Findlay, W. P. K., Chaplin, C. J., and Campbell, W. G. Effect of Progressive Decay by *Trametes serialis* Fr., on the Mechanical Strength of Sitka spruce. *Forest Products Research Bulletin* No. 11. H.M. Stationery Office, 1931. Price 1*s.* 6*d.* net.

Influence of Heart-rot

Some preliminary steps have been taken in an investigation to determine if, in a tree with heart-rot, there is any apparent loss in strength beyond the readily determined apex of the rot core. This investigation is still being pursued.

The Relations between the Structure of Wood and its Mechanical Strength

The first stage has been completed in an investigation of the relationship between the structure and the mechanical properties of English ash, *Fraxinus excelsior* L. As described in the last report, this involves the use of an improved form of bobbin-shaped compression test piece, so designed that the whole cross-sectional area of the specimen under test can be examined microscopically. The results of a series of tests on selected material from two different localities have been analysed statistically and have enabled certain provisional conclusions to be drawn as to the way in which the mechanical strength of the wood is determined by its anatomical structure.

One conclusion of interest that has emerged is that the rate of growth, as expressed in the width of the annual rings, is not of fundamental importance in assessing the strength of ash since it bears no close relation to either the amount of wood substance present or its distribution. The apparent relation between ring width and strength is simply due to the relation between ring width and the percentage of summerwood in the annual ring, and on account of the variation in the thickness of the fibre walls estimates based on ring width alone may be definitely misleading. Consideration of the fact that mechanical strength is a function of the amount of wood substance present in a piece of wood, and that in a ring-porous wood such as ash the wood substance is concentrated in the summerwood fibres (see Fig. 8), suggested a method for estimating the strength of a specimen from a knowledge of its specific gravity and percentage of summerwood in the annual ring. For given values of summerwood per cent. and ring width, any increase in specific gravity will probably be due mainly to increased thickness of the fibre walls and will be accompanied by an increase in strength. These relations were employed to develop a method for estimating the mechanical strength of ash which takes into account both the amount of wood substance present and the distribution of wood substance as measured by the percentage of summerwood, and which appears to be a distinct advance on previous methods. Before the accuracy of the method can be confirmed it will be necessary to

carry out a further series of tests on another consignment of the same timber. It should be mentioned also that there is reason to believe that the chemical composition of the wood will prove to be an additional factor in affecting the strength of ash. This question is under investigation.

A similar series of tests under this project has been started on four consignments of Sitka spruce grown in different parts of Great Britain. A full scale laboratory investigation of the general properties of the timber was the main factor in determining its selection for studying the relations between structure and strength in a typical soft-wood.

Factors affecting the Resistance of Timber to Wear

The problem of devising a suitable test to differentiate between timbers as to their resistance to abrasion, as in flooring, is still engaging the attention of the Laboratory, and a considerable amount of exploration work has been done during the year which it is hoped will lead to its ultimate solution.

As reported last year, the unsuitability of many of the standard abrasion machines led to a general survey of the problem of abrasion as affecting timber. The result was the purchase of an engineer's metal planing machine to be modified and adapted as an abrasion machine for timber. With this machine as a basis, various devices have been designed to impart the abrasive action to the surface of the timber and investigations which it is hoped will produce a satisfactory standard abrasion tool are now going forward. Sections of flooring, made up either from strips or from blocks, and mounted on the table of the planer are being used in these preliminary investigations. The two abrasion tools are attached to spindles mounted on the modified tool box and part of the cross feed has been replaced by a revolving spindle by which the abrasion tools are actuated. One tool acts as a stamp to break the surface fibres and the second tool is a rubber or "scuffer" to remove the broken fibre from the surface. Satisfactory progress has been made and several technical difficulties have been overcome. Further exploratory investigations are being pursued with a view to perfecting certain parts of the mechanism and technique.

Tests of Australian Poles

Efforts have recently been made to introduce into this country fron Australia power transmission and telegraph poles of much denser and stronger timber than the creosoted redwood poles utilized hitherto, and some uncertainty has existed concerning the reduction in size as compared with the sizes of redwood poles now specified, which the greater strength of the Australian poles would permit.

At the request of the Post Office, the Laboratory undertook to carry out mechanical strength tests of a number of poles of ironbark (*Eucalyptus paniculata* Sm.), selected from a consignment of the species which the Post Office imported for purposes of field trial, with the object of evaluating the sizes in which the poles could be substituted. Poles of ironbark (*Eucalyptus paniculata* Sm.), tallowwood (*Eucalyptus microcorys* F. Muell.), and blackbutt (*Eucalyptus pilularis* Sm.) were received at the Laboratory and subsequently subjected to mechanical strength tests.

The report[1] of the investigation has been completed. Although the number of poles available for the investigation was limited, some valuable data resulted from the tests. In addition to an analysis of the position from the aspect of the breaking strength of the poles, their stiffness and weight have been closely examined. The

results confirm that the Australian timbers possess very high mechanical strength properties, ironbark, the strongest, being twice as strong and as stiff as redwood, yet it is shown that when substituted for redwood poles on a basis of equality in breaking strength, the Australian poles are inferior in stiffness and of greater weight, both of which characteristics may in certain circumstances constitute serious disadvantages.

(1) LATHAM, J. *Mechanical Strength Tests of Australian Poles. Project O, Investigation* 61. Available on application to the Laboratory.

The Effect of Creosoting on the Strength Properties of Douglas Fir Sleepers

During 1931, an investigation was commenced by the Timber Mechanics Section in co-operation with the Section of Wood Preservation, to determine any effect which the practice of incising prior to creosoting, might have upon the mechanical properties of Douglas fir sleepers. Mechanical tests were made upon one consignment of incised, creosoted sleepers and significant results were obtained, but these required confirmation.

The necessary timber was procured for repeating these experiments and extending them to cover Baltic redwood for direct comparison, and was stored for air-seasoning prior to creosoting. With a view to exploring the effect of moisture content on the degree of penetration of creosote into the Douglas fir, it was arranged to divide the material into two groups, one for treating at a moisture content of about 27 per cent. and the other at a moisture content of about 20 per cent. The seasoning of the first group was completed in the early summer of 1932 and the sleepers were thereupon creosoted and tested. The remaining group, which took much longer to season, is now ready for testing and this work will be carried out early in 1933.

The Influence of Moisture upon Mechanical Properties

A consignment of oak from Longleat, Wilts., was of particularly clear quality and yielded a large quantity of useful material besides what was needed for the ordinary routine mechanical testing. This additional material was used in special tests in which the test pieces were conditioned to varying percentages of moisture content before testing, with a view to obtaining data relating to the influence of moisture content upon strength and other mechanical properties. This investigation is proving most interesting and useful as affording factors whereby the results of tests on timber with various moisture contents may be compared on a uniform moisture-basis through the application of suitable correction factors. For this work small specimens approximately 1-in. square in section and 4-in. long are used. The relationships between the growth characteristics, specific gravity and moisture content are explored at the same time, as also other related considerations. The tests on this particular consignment have been completed but the results are numerous and the analysis of these is still in progress. Similar tests have also been undertaken on consignments of sycamore and hornbeam. The tests on the latter species have not yet been completed.

Comparative Tests on Laths

A request was recived from a firm dealing exclusively in laths to carry out comparative tests to determine the strengths and relative resistance to splitting of several types of laths. The laths presented for test included hand-made laths of domestic manufacture, sawn laths of different grades as imported from the Baltic, and a clear

grade of laths manufactured under a special process from timber from the Empire oversea. The tests showed that the Empire lath of special manufacture had mechanical properties which rendered it quite equal to the best laths in use and at the same time possessed other features which were likely to render it particularly serviceable.

Weights of Timber

A considerable amount of work was done during the year in collating information on the weights per cubic foot of the more important species of timber in connection with the specifications under consideration by the Building Section of the British Standards Institution. All known references were searched and the data tabulated. The result of the work is of considerable importance as it not only supplies the requirements of the present Committee but will form a very authoritative work of reference.

Box-testing

The economic importance of the efficient design and manufacture of boxes and containers of all kinds has been before the Forest Products Research Board for a number of years past and from time to time the Laboratory has attempted to obtain a sufficiently definite expression of interest from commercial sources to warrant the setting up of a box-testing laboratory. It has been apparent that a considerable amount of interest existed amongst the makers and users of boxes and during the year the matter has been pursued with the definite idea of securing concrete promises to use a box-testing service if it were made available, in the form of a monetary contribution which would, in effect, represent a guarantee to submit boxes for test during the next three of four years after the plant is in operation. Negotiations along these lines are still proceeding.

Standard Tests on Wood Preservatives

Work has continued under this scheme and additional preservatives under test include two patent preservatives of the water-soluble type.

Many of the specimens laid down at the commencement of these tests are now showing signs of considerable decay (see Fig. 9). In some cases, specimens treated with the water-soluble type of preservative are affected although the decay is not nearly so extensive as in the untreated controls. All specimens treated with coal-tar creosote are sound after two years but decay is present in the majority of the untreated controls.

Examination of the failure of the water-soluble type of preservative definitely shows that it is due to leaching of the preservative out of the timber and this is confirmed by the fact that specimens under test in the toxicity chamber which are not exposed to the action of leaching are all quite sound.

Laboratory Testing of Wood Preservatives

The testing of wood preservatives has been continued and further wood block and agar tests have been completed.

The co-operative experiments organised by the Committee set up by the Toxicity Conference in Berlin in 1930, to arrive at some agreed standard methods of testing preservatives, have been continued. The strains of the test fungi which are considered most active have been chosen and will be used in future work.

A carefully controlled test upon two standard antiseptics, which were supplied from one source, is being carried out in a number of laboratories in different countries, to

FIG. 9.—*Standard Tests on Wood Preservatives. Test specimens in the ground showing fungus growth on untreated ends.*

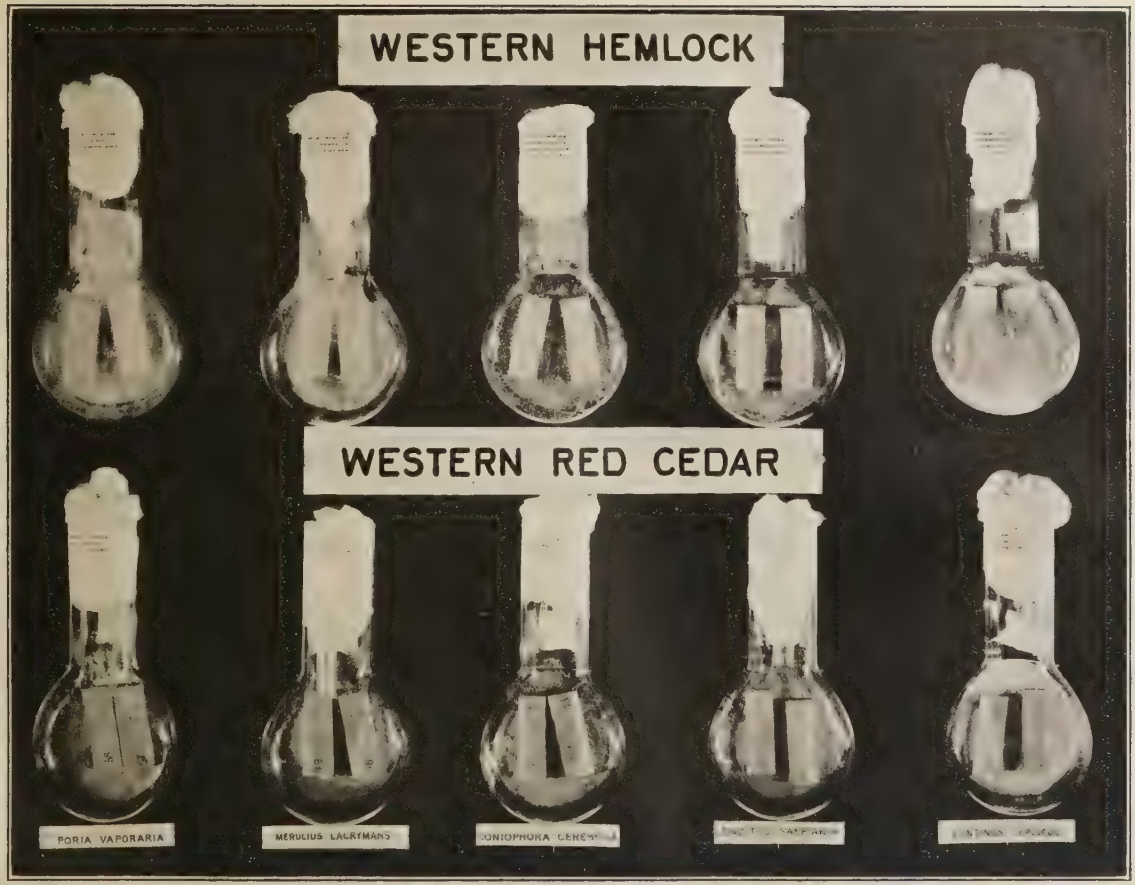


FIG. 10.- *Samples in Culture Flasks after four months' exposure. Note absence of fungus growth on Western Red Cedar samples.*

demonstrate how far the method is capable of giving consistent results by different investigators ; the test which is in progress at the Laboratory will shortly be completed and the results communicated to the International Committee. A paper on the Laboratory Testing of Wood Preservatives was published during the period under review [1].

[1] Findlay, W. P. K. The Laboratory Testing of Wood Preservatives. *Ann. Appl. Biol.*, 1932, **19**, 271.

Mine Timber Durability Tests

The work of supervision and inspection of these tests is being continued. Many of the untreated props show signs of considerable decay whilst all the treated props remain quite sound.

Mechanical Strength Tests of Home-grown Poles

The great majority of telegraph and power transmission poles at present used in this country are imported from abroad. In recent years an increasing number of home-grown Scots pine poles have been used with satisfactory results and there is no difficulty in disposing of poles of the suitable size and shape. There are, however, other home-grown species which may possibly be quite suitable for this purpose but at present cannot be used with any degree of confidence owing to the lack of sufficient data concerning their strength and capability of absorbing creosote.

An investigation of the mechanical and physical properties of poles of home-grown softwoods and of their capability of absorbing creosote has therefore been commenced with the object of furthering the utilization of thinnings from Forestry Commission and other plantations, for telegraph and transmission poles.

For the purpose of the investigation, 100 poles each of Corsican pine, European spruce and Sitka spruce have been supplied by the Forestry Commission. Up to the present only the tests of unseasoned poles have been made. These comprised tests of uncreosoted poles as controls and of poles which had been creosoted for exploratory purposes. The remaining poles have been piled for air-seasoning prior to creosoting and testing.

Fence Posts

In co-operation with H.M. Forestry Commission a large scale durability test on fencing posts has been commenced with the object of testing the efficiency of various methods of preservation. The species under test include home-grown oak, beech, birch, Scots pine, Corsican pine, spruce, Douglas fir, and Japanese larch. The posts have been treated in different ways and together with untreated controls erected as fencing in three different sites, viz., at Princes Risborough, in Norfolk and in North Wales, where widely varying soil and climatic conditions ensure that the results obtained will be reasonably representative of the whole country. The posts have been labelled and a record of their durability will be kept.

One of the problems of forest management is the utilization of the considerable quantities of thinnings which have to be removed from the plantations at certain intervals in order to maintain the proper development of the main crop. One of the important uses of such thinnings is for fence posts but since many species are not durable in an untreated state some form of preservative treatment is required to make them serviceable. From the results of this large scale experiment it is hoped to determine the most economical and efficient methods of preservation and so lead to a considerable increase in the use of plantation thinnings of non-durable home-grown species for fencing.

Field Tests of Natural Durability

The more economic application of antiseptic treatment is that which is applied to timbers which are normally not durable in an untreated condition.

There are several species of timber which are exceedingly durable in a natural state and which do not require preservative treatment. Apart from the well-known examples of oak and larch heartwood there are many of the lesser-known timbers of Empire origin which are reputed to be very durable. In order to obtain accurate data on the natural durability of different species of timber test specimens have been inserted in the ground in three different localities and a record will be kept of their durability. The number, size and condition of specimens have been standardised in order to obtain comparative results, whilst the variations due to climatic and soil conditions have been minimised by testing at three widely differing sites.

Laboratory Testing of Natural Durability

Progress has been made in testing the resistance of various home-grown and Empire timbers to the attack of fungi growing under controlled conditions. A procedure for carrying out standard tests has been laid down and about fifteen different timbers have so far been tested. The method is essentially similar to that employed in the wood block tests of antiseptics. Small sterilised blocks of wood are placed in contact with cultures of wood-destroying fungi growing on media in culture flasks, and the amount of decay which takes place is estimated by determining the loss in weight brought about by the fungus during a definite period. One half of the specimens is removed from the cultures after exposure to fungus for four months and the rest after eight months. The appearance of two series of flasks after four months incubation is shown in Fig. 10 in which it will be noticed that the Western red cedar specimens have remained completely free from all fungus growth.

The Preservative Treatment of Wood with Antispetics

Continuing the study of the effect of the structure of wood on its preservative treatment, special attention has been directed towards those anatomical features which appear to control the passage of liquids through wood. In particular the bordered pits in the tracheids of coniferous timbers have been examined with reference to their numerical distribution and their condition in green and seasoned timber. In connection with the changes which occur in the pits in the process of seasoning, observations have been carried out on the accompanying changes in the liquid conductivity of the wood. Certain anomalies observed in the creosote treatment of Douglas fir on a semi-commercial scale have also been investigated and similar problems with other species have been dealt with.

Timber Insect Survey

Although there is ample evidence of continued losses to the hardwood trade from damage caused by *Lyctus* Powder-post beetles, there has been, as yet, no organised campaign by the industries concerned to deal with the problem. Many industrial concerns have sought advice from the Laboratory and have put its recommendations into practice. Until, however, there is a more united effort on the part of timber merchants and importers on the one hand, and manufacturers on the other, there is little hope of material reduction of this type of damage to timber.

[*To face page* 25

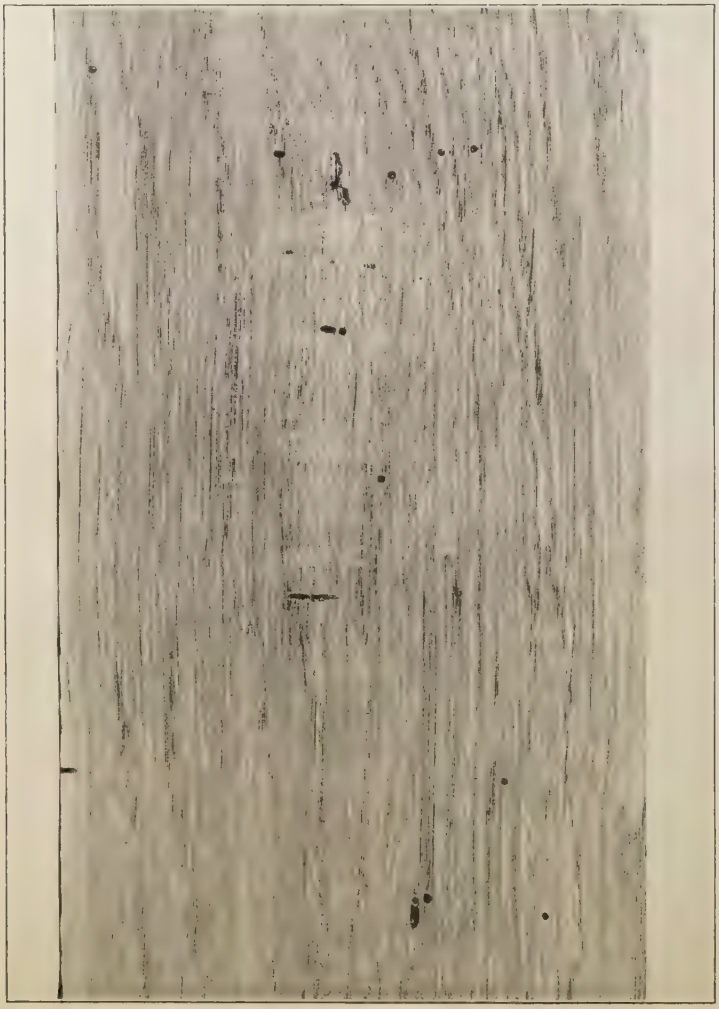


FIG. 11.—*Pin-hole Borer* (Platypus cylindrus) *Damage to English Oak board.* (*Mag.* × $\frac{2}{3}$ *approx.*)

An interesting outcome of the survey work, an account of which[1] was published during the year, has been the increase in the number of requests for information concerning insect defects in Empire timbers. This has led to an extension of the survey to collect data on behalf of the Indian Government upon the occurrence of insect damage in Indian timbers on arrival in this country. A joint scheme has been prepared with the Forest Research Institute, Dehra Dun, the Entomology branch of which is investigating the extent of insect injury to timbers before shipment.

Two records of insects occurring in timber in this country during the year are of special interest. *Lyctus sinensis* has been recorded in Japanese oak, this bringing the number of species of *Lyctus* recorded in Great Britain up to six. Since it originates from a country with climatic conditions somewhat similar to those which prevail here, there is a real danger that *Lyctus sinensis* may become established in timber yards and manufacturers' premises in this country.

The second record, of comparatively little economic importance, though certainly of interest, was of the occurrence of the Bamboo Shot-hole borers *Dinoderus minutus* and *D. pilifrons* in Burma teak. Some alarm was caused among teak shippers as a result of this most unusual occurrence of insect damage. Several consignments were involved and requests for information were received from different parts of the country. Enquiry showed that the damage was merely superficial and accidental, being due to the use of insect infested bamboo as dunnage in the holds of ships in which the teak was carried. During the voyage beetles had emerged from the dunnage and had attempted to bore into the teak. Careful selection of sound bamboo as dunnage should prevent the recurrence of this type of injury.

(1) Fisher, R. C., Cann, F. R. and Parkin, E. A. A survey of the Damage caused by insects to Hardwood Timber in Great Britain. *Forest Products Research Bulletin* No. 16. H.M. Stationery Office. Price 2*s*. 6*d*. net.

Pinhole Borer Damage to Empire Timbers

In the last annual report mention was made of the importance of Pinhole borer damage in relation to the utilization of Empire timbers. On several occasions requests have been received for information upon the origin of this type of injury (see Fig. 11) and upon the possibility of reducing its prevalence in certain of the woods which have recently appeared in the market. The prevention of pin-worm damage, due to insects which attack timber soon after felling and which cease their activities when the timber becomes dry, can be undertaken only in the country of origin. The adoption of suitable methods of handling, storing and seasoning these timbers calls for the dissemination of accurate knowledge upon the mode of attack by the insects responsible. Much useful work can be carried out by forest services or private firms concerned in the felling, extraction, storage and shipment of such timbers as are liable to attack. Every opportunity has been taken of discussing Pinhole borer problems with forest officers visiting or attending the Laboratory for courses of study during the year.

One of the first steps necessary in attempting the control of Pinhole borers is the accurate identification of the species responsible for the damage, upon which, at the present time, little or no information is available. A start has therefore been made to build up a collection of these insects taken from Empire woods after arrival in this country or obtained from infested timbers in the countries of origin. Although the Laboratory cannot carry out direct investigations upon the life-history and methods of control of such species as are found to be of economic importance, it can play a useful part by

acting as a link between the suppliers of timber and the users in this country, pointing out the relative importance of the different types of insect damage and indicating which of these might be controlled or prevented by suitable methods of handling and storing the timber.

Kiln Sterilization

In continuation of the work previously carried out upon heat sterilization treatment[1] of timber for the destruction of *Lyctus*, more precise information has been obtained concerning the effect of this treatment upon the eggs of these insects. Experiments have been carried out to determine the time necessary for the destruction of the eggs of *Lyctus brunneus* and *L. linearis* submitted to a temperature of 130° F. and a relative humidity of 100 per cent. The results, which have been confirmed by repeated experiments, show that an exposure of three minutes is sufficient. This indicates that a lethal treatment involving the exposure of infested timber to the above conditions of temperature and humidity for 1½ to 2 hours for materials 1-in. thick, and for correspondingly longer periods for thicker timber, is more than sufficient to destroy the eggs of both species, and doubtless of other species of *Lyctus* also.

[1] Fisher, R. C. *Lyctus* Powder-Post Beetles. *Forest Products Research Bulletin* No. 2. H.M. Stationery Office, 1929. Price 3*s*. net.

Susceptibility of Timbers to Lyctus *Attack*

The study of the relation of pore-size of timbers to their susceptibility to *Lyctus* attack has been carried a step further. A detailed investigation of the structure of the egg and mode of oviposition of *Lyctus brunneus* has been made, and comparative notes have also been obtained for *L. linearis*, *L. planicollis* and *L. parallelopipedus*. It has been evident for some time from records of *Lyctus* attack in different timbers that a modification of the pore-size theory, as formulated in the earlier stages of the *Lyctus* investigations,[1] was required. The results of the past year's work show that the liability of timber to *Lyctus* infestation depends upon the relationship existing between pore diameter and the ovipositor diameter of the beetle, and not as was previously supposed upon the relationship between pore diameter and the diameter of the *Lyctus* egg. In the light of this modification of the original theory, the occurrence of *Lyctus* in such small-pored timbers as sycamore, willow and the Australian *Schizomeria ovata*, mentioned specifically in the last report, can be explained satisfactorily. The conclusion which has been reached is that, with the exception of such small-pored timbers as horse chestnut, most hardwoods are suitable for egg-laying by the species of *Lyctus* which occur in Britain. A full account of this work and the practical application of the results obtained is in course of preparation.

Although it has thus been possible, from the work of the past year, to determine whether a timber is suitable for oviposition by *Lyctus*, the conditions necessary for the successful development of larvæ are not yet fully understood. A valuable contribution to the knowledge of this part of the problem has been made by Wilson[2] who, as a result of a series of experiments carried out on his behalf at the Laboratory during the past two years, states that the food of *Lyctus* consists of starch. It is hoped that other experiments at the Laboratory, approaching this very interesting question of nutrition from a different angle, will throw more light on the subject. Campbell[3] has already shown that *Lyctus* derives its nourishment from the cell contents and not by digestion

of the wood substance, and this is confirmed by Wilson's work. On the biological side, attempts have been made to remove part of the cell contents of oak sapwood by leaching small samples in various neutral solvents. Leached and unleached samples have been submitted to attack by *Lyctus* and evidence has been obtained that the larvæ are unable to develop normally in sapwood from which certain water soluble substances have been removed. On the chemical side a preliminary investigation of extracts from oak sapwood is being made, and it has already been shown that a polysaccharide which gives a blue colour reaction with iodine-potassium-iodide solution and is an essential factor for normal development can be extracted by comparatively simple means. The investigation of its chemical composition and properties is in progress.

(1) Clarke, S. H. On the Relationship between Vessel Size and *Lyctus* Attack in Timber. *Forestry*, 1928, **2**, 47.

(2) Wilson, S. E. *Lyctus* Powder-Post Beetles. *Nature*, 1932, **130**, 22.

(3) Campbell, W. G. The Chemical Aspect of the Destruction of Oak Wood by Powder-post and Death-watch Beetles, *Lyctus* spp. and *Xestobium* sp. *Biochem. J.*, 1929, **23**, 1290.

The Death-Watch Beetle—Xestobium rufo-villosum

Valuable progress in the investigation of the biology of the Death-watch beetle has been made during 1932. As a result of the work of previous years it has been possible to reproduce in the Laboratory conditions in timber which have proved more suitable for the development of the early stages of *Xestobium* larvæ than those hitherto investigated. Consequently it has been found that larvæ feeding in timber in which these conditions—chiefly of humidity and the presence of decay produced by fungi—occur, have been making much more rapid progress in their development than larvæ which have been under observation for two years under other conditions. Temperature has been shown to have an important effect on the rate of development of the insect, particularly in conjunction with other requisite conditions within the timber. A series of experiments has been carried out to determine the duration of the incubation period of the egg of the beetle under controlled conditions of temperature and humidity. The results show that an increase in temperature, within certain limits, results in a marked reduction of the incubation period and thereby hastens the rate of development of the insect. This information is of particular interest in relation to the progress of attack of Death-watch beetle in the roofs of heated buildings.

A large number of samples of oak and willow have been decayed by various fungi growing in pure culture, to provide suitable material in which to rear Death-watch beetles.

The results of these experiments have enabled useful progress to be made in the preparation of the roof of the experimental building for large scale rearing of the insect. The provision of the requisite conditions in this building has proved a difficult undertaking, but during the year extensive experiments have been carried out by the Section of Seasoning, with the result that a technique has now been evolved which will enable one of the rooms in the upper storey of the building to be used as a controlled temperature-humidity chamber. Entomological work in the roof of the building has therefore been delayed until 1933.

As in previous years the Death-watch beetle studies have been handicapped by an inadequate supply of insects. This was partly overcome by bringing two willow trees known to contain living insects and planting them in a suitable position in the Laboratory grounds. These trees have proved useful not only as a source of material

but also for facilitating the investigation of the conditions prevailing in the natural habitat of the beetle. Further quantities of timber taken from the roofs of buildings and believed to contain active Death-watch beetles and their larvæ have been sent to the Laboratory, but have provided only small numbers of insects. The search for beetles, which do not emerge in numbers and therefore can be found only by detailed examination of timber by chopping and breaking up samples, is a slow and uncertain process, frequently involving fruitless labour.

The Common Furniture Beetle—Anobium punctatum

General work on the life-history of the Furniture beetle has been continued and an investigation of the susceptibility of plywood to attack has been started. In continuation of the series of leaflets dealing with insect damage to timber and methods of control, a leaflet[1] upon the Common Furniture beetle has been published.

[1] The Common Furniture Beetle. *Forest Products Research Leaflet* No. 8. Obtainable from Forest Products Research Laboratory, Princes Risborough. *Gratis.*

Heat Sterilization of Buildings for the Destruction of Anobium punctatum

During the summer of 1932 an opportunity occurred of observing and recording the results of a special hot air treatment, known in this country as the Tubit process and on the Continent as the Deuba process, for the destruction of the Common Furniture beetle in the timbers of an historic barn. In Great Britain this process has been used for drying out new buildings : its value for the destruction of insects in timbers in this country has not previously been investigated. The treatment has been used extensively in recent years in Denmark and Germany for the destruction of the longicorn borer *Hylotrupes bajulus* in roofs constructed of coniferous timbers. Continental workers have shown that a temperature of 55° C. at the centre of the timber maintained for six hours, is sufficient for the destruction of *Hylotrupes* in all its stages. The results of the treatment of the building in this country showed that similar conditions of temperature were more than sufficient to destroy the adults and larvæ of the Common Furniture beetle. The application of the process in its present form is strictly limited, and it is unsuitable for use in the majority of buildings, but with modification might be used as a valuable method of treatment of insect-infested flooring and roofing timbers in such buildings as warehouses, barns, etc.

In connection with the above work, experiments were carried out at the Laboratory to determine the temperature and periods of exposure necessary to kill *Anobium* larvæ. Temperatures of 50° C. (122° F.) and 55° C. (131° F.) were found to be lethal with an exposure of 5 minutes. Larvæ were able to withstand a temperature of 45° C. (113° F.) for 45 minutes but were killed after 60 minutes : the relative humidity was about 30 per cent.

Insecticide Tests

Tests have been continued during the year with a number of proprietary and other insecticides for the treatment of timber attacked by wood-boring insects. An account of this work was contributed to a discussion upon laboratory tests of insecticides at a meeting of the Association of Economic Biologists, and has since been published[1].

[1] Cann, F. R. Laboratory Tests of Insecticides for Use against Wood-boring Insects. *Ann. Appl. Biol.*, 1932, **19**, 291.

Fungus and Insect Association

The study of the association between species of *Sirex* (Wood-wasp) and wood-destroying fungi, has been held up owing to the difficulty of obtaining suitable material. It is of interest to record that a fungus has been isolated in New Zealand from timber containing *Sirex noctilio*. This fungus, though similar to those isolated from species of *Sirex* occurring in this country, is probably not identical with any of them.

Identification and Physiology of Wood-Destroying Fungi

The number of wood-destroying fungi growing in pure culture has been further increased both by isolations from fruit bodies and by exchange with other workers. In view of the growing interest in timbers from the Empire, it is becoming increasingly important to obtain cultures of the principal wood-destroying fungi which occur in the Colonies and Dominions, since it is necessary to be able to recognise the cause of any defect which may be present and to trace its origin—the question frequently arising whether decay originated in the standing tree or after conversion. Generally speaking, the fungi which are isolated can only be recognised if standard cultures made from named fruit bodies are available for comparison. A start has been made on the building up of a collection of cultures of fungi from tropical countries, but progress is bound to be slow unless collections and isolations are made in the various countries concerned. Thanks to the co-operation of the Wood Preservation Officer in the Australian Division of Forest Products, a number of cultures attacking timbers in the Commonwealth has been received.

The collection of fruit bodies of wood-destroying fungi has also been increased and the receipt of a useful collection from the Dominion Botanist in Canada has to be recorded. It is planned to exchange sporophores of these fungi with several workers, both in the United States and in Canada.

A detailed study of the rots occurring in English oak has been started ; descriptions are being prepared both of the rots which occur in the standing tree and those which attack felled timber. The growth of the fungi, both in artificial culture and in wood, is being studied, and certain physiological characteristics determined.

In connection with the general investigation upon the timber of oak, it may be mentioned that the problem of the so-called " brown-oak " is being re-investigated. It was shown by Groom, 1915,[1] that the rich brown discoloration which is sometimes found spreading from the base of the tree up into the trunk is due to the growth of a fungus in the wood, but he did not clearly establish the identity of the organism responsible, stating that *Penicillium* was repeatedly isolated from the wood on which, later, fruit bodies of a *Melanogaster* developed. In the present work, a fungus has been isolated that does not produce *Penicillium* spores. Its power of producing a brown colour in the wood is being examined.

The systematic study of the white species of the genus *Polyporus* has been continued, but is somewhat hampered by the lack of authenticated material and by the difficulty of obtaining agreement as to the identity of the specimens collected.

The rates of growth at various temperatures of a number of important wood-destroying fungi have been determined and a paper which includes a series of graphs and which discusses the usefulness of these for the purposes of identification has been prepared for publication.

The experiments upon the effect of adding varying quantities of nitrogen to the wood upon its rate of decay by wood-destroying fungi have been carried on, and certain

definite results have been obtained. A paper summarising these is being submitted for publication.

Further experiments have been made to determine the influence of the concentration of sugars and of nitrogenous substances upon the fruiting of Basidiomycetes in agar media. It was found that the addition of glucose to a malt agar medium caused the fruit bodies to be larger and more fully developed, while the addition of peptone inhibited their formation.

(1) Groom, P. "Brown oak" and its Origin. *Ann. Bot.*, 1915, **29**, 115.

Dry Rot Investigations

The development of dry rot in the experimental building referred to in the last report has been carefully followed, and records have been kept of the temperatures and the moisture content of the wood in various parts of the building. Active growth of dry rot fungus has taken place on certain types of solid floor, particularly on those in which the boards are laid directly on to concrete and covered with an impervious covering; on the other hand, the provision of a moderately thick layer of bitumen beneath the boards reduces the susceptibility to attack considerably.

In the "bad construction" room, in which there is a hollow floor with no ventilation beneath, the fungus had covered the greater part of the flooring eighteen months after inoculation. The moisture content of the test samples placed in contact with the joists varied between 25 per cent. and 40 per cent. of the dry weight, a moisture content above 27 per cent. only being found in those samples which had been attacked by the fungus.

A comparative test of the resistance to dry rot of two Canadian timbers is being carried out in this room. Alternate boards were removed from an area of floor where the fungus was in active growth, and were replaced by boards of Western red cedar (*Thuja plicata*) and of Western hemlock (*Tsuga heterophylla*). After nine months there were slight signs of attack upon the hemlock, but the red cedar boards were completely free from fungus.

No growth of fungus took place in the "good construction" room, where there is adequate ventilation under the floor, although each section of the floor was twice infected with wood on which *Merulius lacrymans* was in active growth. This demonstrates that good ventilation will prevent the outbreak of dry rot, even if infection be present; it does not mean that a well-established attack by *Merulius* can be checked by ventilation alone, but that an outbreak will not originate in a well-ventilated floor.

The spores of the dry rot fungus (*Merulius lacrymans*) have been successfully germinated in the Laboratory upon malt extract medium, to which 1 per cent. malic acid or 1 per cent. phosphoric acid had been added, as well as upon sound, sterile wood. It has sometimes been stated that these spores which are often very difficult to germinate, are non-viable, but this is evidently not the case, and the spores must always therefore be treated as a dangerous source of infection. In this instance, the spores were tested within a few days after being shed from the fruit body. While it is recorded that the spores of *Merulius* can remain alive for several years, it is probable that with increasing age they become proportionately difficult to germinate and require much longer periods to do so. A note by the Assistant Mycologist, describing the method used to germinate the spores, is in the press[1].

The resistance to dry rot attack of a further number of composition wall boards, including some which are stated to have been treated to resist decay, has been examined.

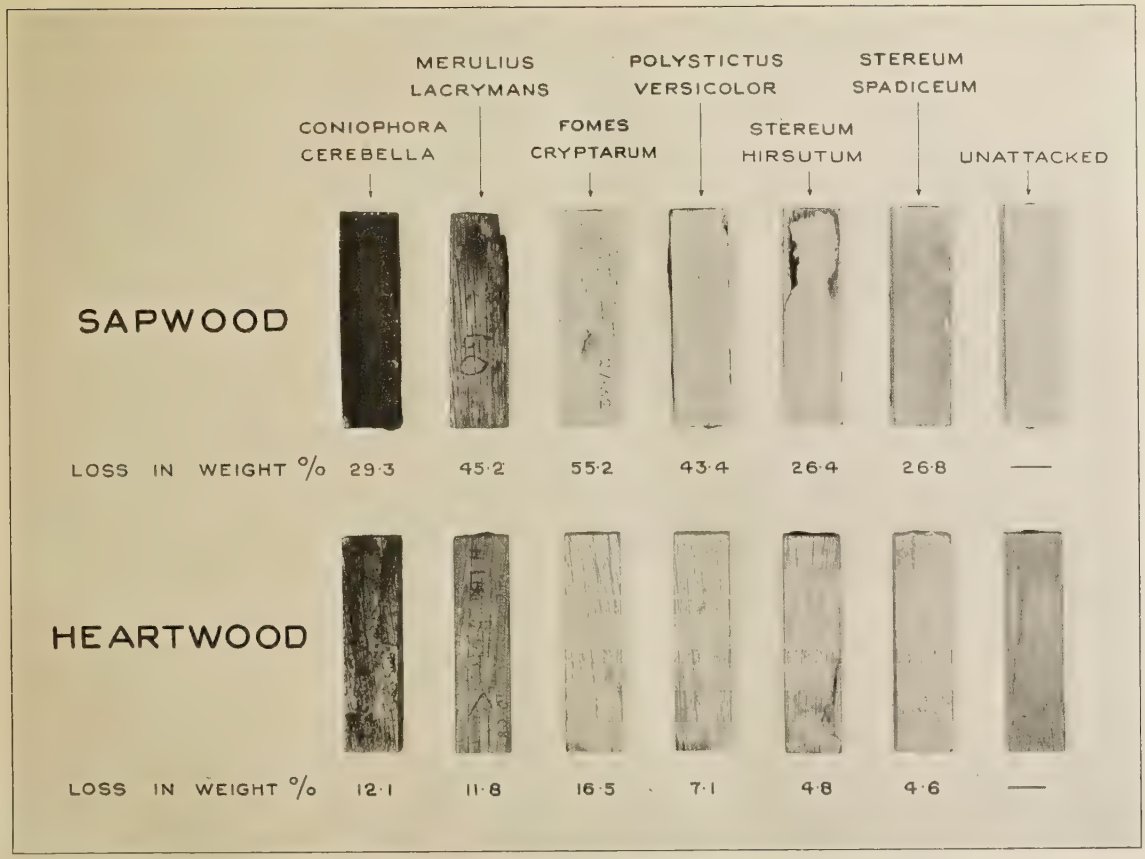


FIG. 12.—*Oak blocks,* $10 \times 2\frac{1}{2} \times 1\frac{1}{4}$ *cm., exposed to attack of various fungi for eight months. Underneath each block is given the percentage loss in weight from decay.*

To face page 31

The edition of Bulletin No. 1, *Dry Rot in Wood*, having become exhausted, the opportunity has been taken to revise[2] it and to incorporate additional matter which has become available during the years which have elapsed since its publication. Parts II and III have been contributed by H.M. Office of Works and the Building Research Station, and deal respectively with measures for treating an outbreak of dry rot and with precautions to be taken in designing buildings so as to prevent outbreaks of dry rot.

A large number of copies of the Leaflet[3] on dry rot have been distributed to enquirers on the subject.

[1] Findlay, W. P. K. The Germination of the Spores of *Merulius lacrymans*. *Trans. Brit. Mycol. Soc.*, **1933**, **17**, 334.

[2] Dry Rot in Wood. *Forest Products Research Bulletin* No. 1. Revised edition. H.M. Stationery Office, 1933. Price 1*s*. net.

[3] Dry Rot in Buildings. Recognition, Prevention and Cure. *Forest Products Research Leaflet* No. 6, 1931. Obtainable from Forest Products Research Laboratory, Princes Risborough, Bucks. *Gratis*.

The resistance of the timber to fungal decay may be expressed as the percentage of the original weight remaining at the end of the experiment. Fig. 12 gives some percentages obtained for blocks of the heartwood and the sapwood of English oak when exposed to six different fungi for eight months. The difference between the resistance of the sapwood and of the heartwood of this species illustrated in the same figure is striking and is in accordance with practical experience. The durability of oak may be taken as a standard with which the durability of newly introduced species may be compared.

A note discussing the durability of Scots pine and describing the principal diseases to which the timber is prone, was published in the Scots pine Bulletin issued by the Laboratory[1].

[1] The Timber of Home-grown Scots pine (*Pinus sylvestris* L.). *Forest Products Research Bulletin* No. 15. H.M. Stationery Office, 1932. Price 5*s*. 0*d*. net.

The Chemistry of Decay

Research on the chemistry of the white rots of wood has been continued and the respective effects on wood substance of a further five representative fungi have been studied[1]. The work on *Armillaria mellea* (Vahl.) Fr., which is referred to in the 1931 report, has been supplemented with the result that it is now possible to state that in the advanced stages of its attack on wood this fungus is capable of attacking lignin. Ten separate species of white rot fungi have now been investigated and the results obtained tend to strengthen a previous conclusion that all fungi of this type decompose carbohydrates as well as lignin, although there is no general uniformity with regard to the order or proportion in which the several wood components are decomposed.

The evidence suggests that the white rots can be subdivided on chemical grounds into three distinct groups as follows :—

(1) White rots in which lignin and pentosans are attacked in the early stages, and in which the incidence of the attack on cellulose is delayed.
Representative fungus—*Polystictus versicolor* (Linn) Fr.[1]

(2) White rots in which cellulose and its associated pentosans are attacked in the early stages and, in which the incidence of the attack on lignin and pentosans not in the cellulose is delayed.
Representative fungus—*Armillaria mellea* (Vahl.) Fr.[2, 3]

(3) White rots in the early stages of which both lignin and cellulose are attacked but in varying proportions.
Representative fungi—*Ganoderma applanatum* (Pers.) Pat., *Polyporus adustus* (Willd.) Fr., *Pleurotus ostreatus* (Jacq.) Fr. and *Polystictus abietinus* (Dicks.) Fr.

It would appear that the ultimate primary reactions involved in all white rots are oxidation and hydrolysis, and that the main variants on which the above subdivision depends are (i) the incidence in point of time of the primary reactions, (ii) the course of secondary reactions if any and (iii) the rates of the several reactions. A further generalisation appears to be that in white rots the total alkali-solubility of the decayed wood when expressed as a percentage by weight of oven-dry sound wood rises to a maximum and begins to decline at a much earlier stage than in brown rots.

(1) Campbell, W. G. The Chemistry of the White Rots of Wood. I. The effect on wood substance of *Polystictus versicolor* (Linn.) Fr. *Biochem. J.*, 1930, **24**, 1235.
(2) Campbell, W. G. The Chemistry of the White Rots of Wood. II. The effect on wood substance of *Armillaria mellea* (Vahl.) Fr., *Polyporus hispidus* (Bull) Fr., and *Stereum hirsutum* Fr. *Biochem. J.*, 1931, **25**, 2023.
(3) Campbell, W. G. The Chemistry of the White Rots of Wood. III. The effect on wood substance of *Ganoderma applanatum* (Pers.) Pat., *Fomes fomentarius* (Linn.) Fr., *Polyporus adustus* (Willd.) Fr., *Pleurotus ostreatus* (Jacq.) Fr., *Armillaria mellea* (Vahl.) Fr., *Trametes pini* (Brot.) Fr., and *Polystictus abietinus* (Dicks.) Fr. *Biochem. J.*, 1932, **26**, 1829.

The Chemical Changes induced in Wood by Heating at Moderately High Temperatures

Until comparatively recent times the chief interest in the thermal decomposition of wood has been centred in the exothermic reaction which gives rise to the well-known products of the wood distillation industry, but until the publication of a series of results in connection with the chemical aspect of the drying of timbers[1, 2, 3] it was not generally realised that even at temperatures lower than 105° C. wood is subject to slight, but none the less, definite chemical changes. These results have been referred to in previous reports but investigations have since been made in this and other Laboratories of the chemical changes which take place in hardwoods and softwoods respectively at temperatures of from 109° C. to 156° C. Hawley and Wiertelak[4] have shown that when wood is heated in sealed tubes at 135° C. for 4 to 8 days a marked chemical change takes place in the cellulosic component. In hardwoods a portion of the pentosans associated with the cellulose is transformed into a product which is insoluble in 72 per cent. sulphuric acid and closely resembles lignin. In softwoods a similar product is formed from the hexosan portion of the cellulose. More recent work by Slavik[5] points to the conclusion that there must be a maximum temperature above which this change is precluded since, after heating wood in air for periods of days at 145° C. this investigator found that while the insoluble product was formed in the softwood under examination it was not formed in a hardwood (beech). As a result of a more detailed investigation[6] it has been found that when wood is heated in the presence of satuated steam under pressure, ranging from 20 to 80 pounds per square inch, that is to say at temperatures of from 109° C. to 156° C. it appears to undergo the same order of chemical change as when heat is applied by other means; with the added consideration that the water vapour present at the outset catalyses the primary reactions to the extent that stages hitherto only reached in a period of days at temperatures of 135° C. to 145° C. can be attained in a few hours at much lower temperatures. By adopting these milder experimental conditions it has been possible to obtain a much closer insight into the mechanism of the thermal

decomposition of wood. For instance, it would appear that the first stage in the decomposition consists in the splitting off from the Cross and Bevan cellulose of anhydro-sugar residues. In hardwoods these residues are mainly pentosans and in the softwoods they are mainly hexosans. Depending upon the conditions under which the wood is heated, there is a temperature below which these residues can condense to form a product which is insoluble in 72 per cent. sulphuric acid and above which they are more or less completely hydrolysed to reducing sugars. At the higher temperatures part of the reducing sugars so formed are decomposed into volatile products. Under uniform conditions of heating the temperature at which the tendency towards hydrolysis of depolymerised sugar residues is greater than the tendency towards condensation to a lignin-like product is lower for hardwoods than for softwoods in view of the well-known fact that pentosans are relatively less stable towards hydrolysis than hexosans. In the presence of steam the critical temperature for both types of wood is doubtless considerably lower than it might otherwise be since in this medium the conditions for hydrolysis are naturally more favourable.

In a later section of this report it is indicated that treatment of the wood of African pencil cedar (*Juniperus procera*) with saturated steam under pressure may find practical application as a softening agent but in certain of its aspects the work described in the foregoing paragraph is of fundamental importance in wood chemistry. For instance a suggestion has been put forward by Hawley and his collaborators[7] in the United States Forest Products Laboratory that the substance formed from the cellulose of wood by heating at 135° C. is similar in composition and properties to natural lignin. If this be true the so-called "synthetic lignin" offers possibilities for future research into the mechanism of the lignification process, since it has long been held by certain investigators that the lignin of wood is a transformation product of cellulose and not, as certain other theories would suggest, an incrusting substance laid down independently of the cellulose.

[1] Campbell, W. G., and Booth, J. The Chemical Aspect of the Drying of Timber. *Biochem. J.*, 1930, **24**, 641.

[2] Campbell, W. G., and Booth, J. The Chemical Aspect of the Drying of Timber. 2. The drying of a softwood. *Biochem. J.*, 1931, **25**, 756.

[3] O'Dwyer, M. H. The Hemicelluloses of the Wood of English oak. 1. The effect of the drying of wood on the yields and composition of hemicellulose A. *Biochem. J.*, 1931, **25**, 2017.

[4] Hawley, L. F., and Wiertelak, J. Effect of Mild Heat Treatment on the Chemical Composition of Wood. *Ind. Eng. Chem.*, 1931, **23**, 184.

[5] Slavik, J. The Effect of Moderate Heat on the Chemical Composition of Wood. *Chem. Listy.*, 1932, **26**, 211.

[6] Campbell, W. G., and Taylor, K. F. The Chemical Changes induced in Wood by Saturated Steam under Pressure. *Biochem. J.*, 1933, **27**, 158.

[7] Hawley, L. F., and Harris, E. E. Synthetic Lignin. *Ind. Eng. Chem.*, 1932, **24**, 873.

The Relationship between the Hemicelluloses and Lignin

From time to time it has been observed that a product can be obtained from hemicellulose which is insoluble in 72 per cent. sulphuric acid. Gerhradt[1] claims to have isolated 15 per cent. of such a substance from the hemicellulose of apple wood. In the course of the work on the hemicellulose of oak wood O'Dwyer[2] has observed that a small insoluble residue is obtained after hydrolysis, even with dilute sulphuric acid, and when hemicellulose A is heated in the presence of air at 135° C. it undergoes a pronounced darkening in colour which is accompanied by a certain amount of decomposition. The residue however contains 8 to 10 per cent. of a lignin-like substance which is insoluble in 72 per cent. sulphuric acid and which, unlike the product of the

thermal decomposition of cellulose, contains methoxyl groups. It has frequently been suggested that the lignin in wood originates from the hemicelluloses and the study of the relationship between the two components is being continued.

(1) Gerhardt, F. The Effect of Acid and Alkaline Hydrolysis on the Estimation of Hemicellulose and Associated Groups in Young Apple Wood. *Plant. Physiol.*, 1929, **4**, 373.

(2) O'Dwyer, M. H. Recent Advances in the Study of the Chemistry of the Hemicelluloses of Wood. *J. Soc. Chem. Ind.*, 1932, **51**, 968.

The Lignin Determination in Wood Analysis

In view of the results referred to in the preceding paragraphs and the work which is in progress on the effect of acid hydrolysis on woods in general, it has been considered that some modification may be necessary in the lignin determination as it is ordinarily applied to woods. Current investigations in this and other laboratories indicate that under certain conditions the concentrated mineral acids used in standard lignin determinations produce insoluble products from the carbohydrate components of wood. Experiments are therefore in progress with a view to determining whether the error thereby introduced can be satisfactorily eliminated.

The Chemical Composition of Wood Smoke as used in the Curing of Fish

This investigation has now reached a stage at which the results obtained can be applied in full scale fish curing experiments at the Torry Research Station. During the year under review a more extensive series of experiments has been carried out in co-operation with the staff of the Torry Research Station in order to determine the influence of the conditions of burning of oak sawdust on the yield and composition of the resultant smoke. The experimental method consisted in admitting air at different measured rates to standard samples of sawdust during burning. During each experiment regular readings were taken of the temperature, density and relative humidity of the smoke, and a chemical analysis was carried out on that portion which condensed on passing through an ice-cooled condenser.

The results indicate that while within fairly broad limits variations in the amount of air supplied to sawdust during burning produce only slight variations in the actual amounts of the constituents found in the smoke which are considered to be effective in fish curing, the three most important variables from the practical standpoint are the temperature, density and relative humidity of the smoke respectively.

The general conclusion has been made that, in order to effect uniform curing, the varying temperature effect of the sawdust fire must be eliminated. This means that smoke should preferably be produced outside the chamber in which fish are to be cured and so conditioned as to be delivered to the fish at a definite temperature, density and relative humidity. It is conceivable that success will also depend on the condition of the fish prior to curing.

Stone-like Deposits in Wood

From time to time the attention of the Laboratory is drawn to abnormalities in timber. One of the most interesting examples submitted for examination in recent years consisted of a large stone-like deposit found in the heartwood of a log of iroko (*Chlorophora excelsa* Benth. and Hook. f.).

Such deposits are not uncommonly found in this wood and the general opinion appears to be that they consist largely of calcium carbonate and are formed in cavities as a result of the gradual loss of water and carbon dioxide from exuding sap.

The specimen referred to above was found to consist of organic as well as inorganic material. The inorganic portion was found to consist mainly of calcium carbonate but by far the most interesting feature was that in addition to chips of wood and a brown powder consisting mainly of small particles of wood the deposit was rich in insect remains. These are described in a short published note[1] in which the origin of the deposit is discussed. There would appear to be little doubt that the initial cause of the abnormality is a wound in the growing tree. Since difficulty and often danger is associated with the conversion of logs containing such deposits, the obvious inferences to be drawn here are that wounds of growing trees of this species should be guarded against or suitably treated and that, prior to conversion, logs from old trees showing any signs of wounds or decay should be closely scrutinised.

(1) Campbell, W. G., and Fisher, R. C. The Composition and Origin of "stone" in Iroko Wood (*Chlorophora excelsa* Benth. and Hook f.). *Emp. For. J.*, 1932, **11**, 244.

Information regarding British Empire Timbers of Home and Oversea Origin

The use of Laboratory Leaflet No. 5[1] has proved of immense value in dealing with enquiries, and there has been an increasing demand for this publication and consideration is now being given to a further edition revised and enlarged as knowledge of the subject has expanded. The book entitled *A Handbook of Empire Timbers* issued by the Empire Marketing Board includes tables of uses and information on veneers and plywoods, and has met with wide appreciation. This is mentioned as the Laboratory contributed largely to the preparation of the work. The greater interest now being manifested in Empire timbers of both home and oversea origin was more than sufficient justification for the publication of this work.

(1) Cosgrove, J. R. Empire Timbers from Home and Overseas for Building and Structural Purposes. *Forest Products Research Leaflet* No. 5. H.M. Stationery Office, 1932. Price 1*s.* 3*d.* net.

Investigation into the Working and Finishing Qualities of Wood

The progress made during the last twelve months has been considerable, as, in addition to the routine tests of both major and minor character carried out on home-grown and oversea Empire timbers, preliminary exploratory work of importance has been completed with relation to the improvement in the technique of woodworking from the engineering standpoint. The investigations under the latter heading were concerned with the factors connected with sawing and planing affecting energy consumption.

Special automatic apparatus has been devised and constructed with the object of eliminating the human element in operating instruments for measuring energy consumption and with a view to ensuring maximum accuracy in the results. The apparatus has proved very satisfactory and its use has made possible the determination of the relationship between the energy consumed and the factors enumerated below : —

(1) Depth of cut	In planing.
(2) Rate of feed	
(3) Orientation of growth rings	
(4) Tooth hook	In sawing.
(5) Tooth spacing	
(6) Tooth set	
(7) Orientation of growth rings	

Effect of Variation of Cutting Angle on Machine Finish

Preliminary tests have been carried out on an over-hand planer in connection with the effect of varying cutting angle by front honing. The results have shown promise, justifying further investigation in conjunction with the apparatus now about to be put in use for estimating the quality of machine finish. A device has been constructed to determine the effect on the surface of cut of varying the angle at which stationary tools are offered to rotating wood specimens. An alternative design to the patented cutter-block for planing and moulding machines, allowing adjustment to the cutters so that the cutting angle may be varied, has been devised by Mr. Philip Harris, B.Sc. (Eng.), and a patent application has been filed with the Patent Office.

Measurement of Quality of Machine Finish

In continuation of previous experiments to determine suitable methods of measuring the quality of the surface produced by the machine for different settings and speeds of the tool, rate of movement of the wood, etc., special apparatus has now been designed and constructed at the Laboratory. The general principles employed in this machine are as follows :—the wood specimen is moved at any pre-determined uniform speed between 18 and 144 inches per minute by means of a suitable driving mechanism to a carriage moving on a metal runway. Linen tapes are drawn slowly under loaded rollers which press the tapes against the moving wood surface. The varying tension in the tapes due to the frictional resistance of the wood is measured by an epicyclic train dynamometer actuating a pen which records the relative roughness of the surface on a chart. One inch of tape is drawn under each roller for 9 inches of wood moved so that the portions of the tapes in contact with the wood are renewed continuously and a standard quality of tape surface is maintained. Some difficulty was experienced with the device in the initial tests owing to the inertia of certain parts causing lag in the pen operation but simplification of the movement has given greatly improved results, and it is considered that the apparatus when perfected will prove eminently satisfactory for its intended purpose.

An investigation was carried out to determine the variability of personal estimation, by both sensory and visual methods, of relative smoothness and the results obtained clearly indicated the necessity for a mechanical means of recording the quality of machine finish.

Liaison with Woodworking Industry

Twelve firms connected with the wood-using industry and eight manufacturers of woodworking machinery and tools have been visited in connection with work on the machining and sawing of timber.

Testing of Timbers to Determine their Working Properties, and to estimate their Value from a Utilization Standpoint

Major scale woodworking tests have been carried out on the following species :—

Oak (*Quercus sessiliflora* Salsib.) from Walcot, Salop—air-dried and kiln-dried.
Oak (*Quercus Robur* L.) from Bedgebury, Kent—air-dried and kiln-dried.
Oak (*Quercus Robur* L.) from Salcey, Northants.—air-dried and kiln-dried.
Oak (*Quercus Robur* L.) from Oakenhill, Glos.—air-dried.
Oak (*Quercus Robur* L.) from Nagshead, Glos.—air-dried.

Oak (? *Quercus sessiliflora* Salisb.) from Dymock, Glos. —air-dried.
Oak (*Q. Robur* × *sessiliflora*) from Brandon, Suffolk —air-dried.
Oak (*Quercus sessiliflora* Salisb.) from Wigmore Rolls —air-dried.
Western hemlock (*Tsuga heterophylla* Sarg.) from British Columbia —air-dried and kiln-dried.

A complete report on oak has been prepared for incorporation in the bulletin now in preparation on this species. Reports differing in nature somewhat from the above have been prepared on the working qualities of the following species of timber : -

Sitka spruce (*Picea sitchensis* Carr.) from Leighton, Wales —kiln-dried.
Sitka spruce (*Picea sitchensis* Carr.) from Banchory, Scotland—kiln-dried.
Sitka spruce (*Picea sitchensis* Carr.) from Bedgebury, Kent —kiln-dried.
Sitka spruce (*Picea sitchensis* Carr.) from Holkham, Norfolk —kiln-dried.
Lowland fir (*Abies grandis* Lindl.) from Leighton, Wales —kiln-dried.
European spruce (*Picea Abies* Karst.) from Banchory, Scotland—kiln-dried.
Birch (*Betula* sp.) from Highclere, Hants. —air-dried then kiln-dried.
Rhodesian mahogany (*Khaya nyasica* Stapf) from Rhodesia—air-dried.

Industrial or Semi-commercial Tests on Timber

In order to permit the wood-using industries and other possible users, to secure first-hand knowledge of timbers which are considered of sufficient promise to undergo full scale tests at the Laboratory, it has been found advantageous to supplement these with commercial tests upon substantial quantities of the material, which, after conversion and seasoning to the requirements of those possible consumers who consent to make such observed trials, are sent to them to use in the ordinary course of their production.

Certain timbers from New Zealand, Ceylon and British Honduras have been submitted to trials of this type. In addition, a commercial test has been carried out upon Munyama (*Khaya anthotheca*), supplied from Uganda. Arrangements were made with firms representing joinery, furniture and cabinet making, and railway carriage building industries to carry out tests on material previously converted and seasoned at the Laboratory to suit the requirements of each of the participating firms. In addition, material from a consignment of home-grown Sitka spruce (*Picea sitchensis*) has been prepared and submitted for commercial tests to firms interested in box and case making, barrel making, organ building and building work as shelving and boarding.

Eight panels in reconditioned home-grown Common and Dutch elm, all different in construction, have been fixed in the lobby of the main Laboratory block, to permit of observations being kept upon the stability of the timber when dealt with by special methods. This, together with the reconditioned elm flooring blocks laid in the entrance hall, may serve to demonstrate the possibility of more extensive use of an admittedly fine British-grown timber, which, unless dealt with scientifically, is known to be refractory and liable to give trouble.

Examples of Co-operation work with Public Authorities, Professional Associations and Government Departments

Specifications have been prepared in collaboration with the Chief Engineer and Chief Architect of the London County Council for the timbers used in Housing Schemes, while inspections have been made of shipments of timber upon arrival, to determine their fitness for use.

Material progress has been made in the preparation of unified timber specifications for use by the timber-using Departments, under the work performed by the Sub-Committee on Building Materials of the Inter-Departmental Works Committee.

In the earlier part of the year some weeks were devoted to the preparation of notes and discussions in connection with a detailed examination of the Empire timber situation for the Ottawa Conference, as well as the economic aspect of the case with respect to tariffs upon foreign timbers, alternative supplies from Empire sources, and so forth. After careful study of the timber situation following the Ottawa Conference proposed standard specifications for building and joinery timbers were prepared and furnished to the Royal Institute of British Architects, as a basis for negotiation between the Institute and the Timber Trade Federation with a view to ultimate agreement upon a standard timber specification for building work.

At the invitation of the British Standards Institution contact was maintained with the British Columbia Timber Delegation which visited Great Britain in the late autumn, when information was given upon the possible utilization of British Columbia timbers.

Work has been continued with H.M. Forestry Commission Advisory Committee on home-grown timbers and their possible development, and there has been active co-operation with the personnel of the Commission in connection with tests, exchange of information, etc.

Exhibits, Specimens and Samples

Thirty-three specimen planks were prepared from incomimg consignments and added to the collection displayed in the Laboratory : in addition a large number of specimen pieces and samples of timber have been supplied to public bodies, architects, firms and individuals. The value of such authentic samples has been demonstrated on many occasions.

Timbers for Ornamental Turnery

In continuation of the investigations of fancy turnery woods mentioned in the report of last year, some sixty-three cylinders of seven species of wood were supplied to Mr. A. L. Hetherington for further tests. His work and investigations and the issue of his booklet[1] on the subject has aroused interest in several Empire decorative woods. A number of pieces originally prepared for these tests, and now surplus, are for disposal, and arrangements have been made with the Worshipful Company of Turners, London, for these to be offered for sale to persons interested. The interest taken in the work and publication carried out by Mr. Hetherington has been very gratifying.

[1] Hetherington, A. L. British Empire Hardwoods from the Point of View of Turnery. H.M. Stationery Office, 1931. Price 2*s.* 0*d.* net.

Charcoal Investigations

Further experimental work was carried out with the Buchanan-Harris portable kiln at the Laboratory, in the carbonization of elm, karri, jarrah and Scots pine : one kiln charge of each and four kiln charges of birch for subsequent activation tests were dealt with.

The use of syphon air-inlet pipes was tested and found to give very satisfactory results, yielding a higher percentage of charcoal, and considerably facilitating the control of burning. Owing to lack of funds this work was discontinued. Twenty-one

enquiries were dealt with during the year, connected with timbers suitable for charcoal, three of which were from firms oversea. Several enquiries were also dealt with regarding the use of charcoal in gazogenes to produce gas for use as a substitute for petrol gas.

III. ADVISORY WORK

(*United Kingdom Section*)

General Advisory Work

The advisory work is a very important branch of the Laboratory's activities, and considerable demands are made on the time of the Director and the senior officers in dealing with enquiries from Government Departments, private firms and individuals relating to questions of policy in developing new timbers or extending the use of others already known. In addition many other enquiries of a less general nature are dealt with by the various sections of the Laboratory. Brief details concerning the work of the Sections in this direction follow.

The Laboratory now advises H.M. Office of Works and other Government Departments on all subjects connected with the use of timber. This work has involved several cases of some magnitude on which it has been necessary to spend considerable time. The London County Council also consults the Laboratory on matters connected with the prevention of decay in timber.

Utilization

Some five-hundred enquiries were received and disposed of as against a total of three-hundred-and-forty-three for the preceding year. These enquiries cover many branches of the timber and allied trades; several coming from oversea. The number of visitors, many of whom are from abroad, is further evidence of the increasing interest taken in the work of the Laboratory.

The Structure and Identification of Wood

The amount of advisory work referred to the Wood Structure Section has again shown an increase over that of the previous year. In addition to numerous requests for the identification of wood in various stages of its manufacture, enquiries have been received from importers and users of timber respecting variation in quality and the nature of defects due to natural causes or faulty manufacture. Questions affecting the abnormal behaviour of specimens in Laboratory tests have in several instances led to a detailed examination of their structure. These cases have been of value in throwing new light on the relation between the structure of wood and its technical properties.

Seasoning

There was a big increase in the number of enquiries pertaining to seasoning during the year under review.

About 80 per cent. of these were from trade sources asking for advice and assistance in practical problems in connection with kilns, drying, and the moisture relations of timber.

Timber Mechanics

There is also to report a very large increase in the number of requests from architects, builders, timber merchants, furniture manufacturers, motor-body builders and others,

for information concerning the mechanical and physical properties of timbers, which is satisfactory evidence that those concerned with the utilization of timbers are now realising the value of such data where the adoption of substitute timbers is under consideration. These data are proving of particular value with the Empire timbers now being introduced and the comparison which may readily be made with the properties of timbers now in use enable potential uses and markets to be readily ascertained.

Increasing appreciation of the value of laboratory tests for the elucidation of specific problems is reflected in the considerable increase in the number of requests by outside bodies for mechanical strength tests. Many of these requests have been for tests to determine the extent to which blemishes, defects, methods of treatment, etc., affect the mechanical strength properties of the material relative to particular uses.

Wood Preservation

Advisory work on preservatives and methods of preservation continues to occupy a considerable part of the work.

Dry Rot and other Mycological Enquiries

The number of enquiries received during the year which refer to questions of decay or deterioration of timber has again increased and is over 50 per cent. greater than in the previous year. A large number of these have referred to decay in buildings which usually has been due to the attack of *Merulius lacrymans* or *Coniophora cerebella*, though a number of other fungi have been identified in material from buildings, the following being some of the more interesting—*Lentinus lepideus*, *Polystictus versicolor*, *Fomes ferruginosus* and *Stereum frustulosum* from window frames; *Fomes cryptarum* and a number of species of *Poria*, some of which have not yet been identified.

Among subjects of special enquiry, may be mentioned :—

1. Staining in obeche (*Triplochiton* sp.).
2. Decay in motor car bodies in the tropics.
3. Resistance to decay of timber treated with various paints.
4. A preliminary investigation into the causes of discoloration in mechanical wood pulp for paper manufacture.

Damage by Wood Destroying Insects

The number of enquiries dealt with by the Entomology Section has shown a large increase during 1932 when 322 were received as compared with 186 in 1931. The majority of these referred, as in previous years, to damage caused by the Death-watch, Furniture and Powder-post beetles, and concerned identification of the insects together with information upon methods of prevention and control. There has also been a marked increase in the number of enquiries concerning insect attack in Empire timbers.

Numerous inspections of buildings or timber premises have again been carried out on behalf of private firms or individuals and information upon the conditions found, together with recommendations for treatment, have been provided. Most of these inspections have dealt with buildings attacked by Death-watch beetles and have been carried out at the request of, and in co-operation with, the architects in charge of the repairs.

Representation on Outside Committees

The Laboratory is represented on the following Committees :

Standing Committee on Empire Forestry :
(*Representative :* Director of Research).

Empire Forestry Association :—

Standard Names for Timbers—Sub-Committee
(*Representatives :* Director of Research.
Officer in Charge, Utilization).

Governing Council
(*Representatives :* Director of Research.
Officer in Charge, Utilization).

Publications Committee
(*Representative :* Officer in Charge, Publications and Records).

British Standards Institution :—

Building Industry Committee
(*Representative :* Officer in Charge, Utilization).

Revision of Aircraft Timber Specifications
(*Representatives :* Officers in Charge, Seasoning and Timber Mechanics).

Aircraft Technical Committee AC2 on Timber, Glue and Casein Cement
(*Representatives :* Officers in Charge, Seasoning and Timber Mechanics).

Sub-Committee, Standard Definitions and Tests for Fire Resistance and Incombustibility
(*Representative :* Scientific Assistant, Timber Mechanics).

Sub-Committee on Transmission Poles
(*Representative :* Officer in Charge, Timber Mechanics).

Technical Committee BG/19, Units Weights of Building Materials
(*Representative :* Officer in Charge, Seasoning).

Sub-Committee on Revision of Timber Section of the British Standards Glossary of Aeronautical Terms
(*Representative :* Officer in Charge, Timber Mechanics).

Sub-Committee—Specifications for Commercial Plywood
(*Representative :* Scientific Assistant, Utilization).

Empire Marketing Board : —
Empire Timber Publicity Committee
(*Representative :* Officer in Charge, Utilization).

Representation on Outside Committees—contd.

The Laboratory is represented on the following Committees—*contd.*

Imperial Institute :—

Advisory Committee on Timbers

(*Representative :* Officer in Charge, Utilization).

Inter-Departmental Works Sub-Committee on Building Materials

(*Representative :* Officer in Charge, Utilization).

British Wood Preserving Association :—

(*Member of Council :* Director of Research).

Publications Committee (Co-opted)

(*Representative :* Officer in Charge, Wood Preservation).

Technical Committee

(*Representatives :* Officers in Charge, Entomology, Wood Preservation, and Scientific Assistant, Mycology).

Association of Economic Biologists :—

(*Member of Council :* Officer in Charge, Mycology).

Imperial Conference :—

Forestry Sub-Committee

(*Representative :* Director of Research).

Board of Education :—

Committee on Examination of Wood Cutting Machinists

(*Representative :* Scientific Assistant, Utilization).

Forestry Commission :—

Advisory Committee on Forestry Research

(*Representative :* Director of Research).

Utilization of Home-grown Timbers

(*Representatives :* Director of Research.
Officer in Charge, Utilization (Co-opted)).

The Laboratory has been deeply interested in the project that has been urged from various quarters in the timber-using industries to establish standard grades of timber for buildings. Steps were taken some years ago, as already reported, to obtain co-operation from the Royal Institute of British Architects and the Timber Trades Federation. These efforts have now borne fruit and a technical committee for the purpose of standardising timber grades has been set up under the British Standards Institution and a sub-committee has been established to carry on the executive work under the Chairmanship of an officer of this Laboratory.

As examples of the application of what has been said above it may be mentioned that during the past year the Laboratory was requested to appoint a representative to

the Sub-committee on Joinery of the British Standards Institution. This Committee had in hand at the time the drawing up of a specification for standard doors to be used principally in housing schemes. The Laboratory was able to contribute technical advice relating to the condition of seasoning which should be sought in the timber before it was manufactured and also as to the restrictions which should be placed upon the amount of sapwood included in the manufactured parts. As a result, the specification issued by this Committee through the Building Section of the Institution contained a definite specification of moisture content.

The Laboratory was also represented on a sub-committee dealing with the review of the nomenclature of timber for aircraft purposes included in the standard glossary of aeronautical terms issued by the British Standards Institution.

The Committee completed its work and it is understood that a revised glossary will appear shortly.

IV.—WORK FOR THE EMPIRE OVERSEA

1. General

General Progress

The Empire Timbers Committee has continued to function in its advisory capacity and the work carried out under its auspices during the year has again shown a marked increase in volume. This may be attributed partly to the change which has taken place in the fiscal policy of the country, partly to the fluctuations in the rates of exchange in various countries and partly to an increasing desire to utilise materials obtained from Empire sources in preference to foreign materials. The work of investigating the properties of Empire timbers at the Forest Products Research Laboratory, Princes Risborough, has shown a corresponding increase.

During the year major scale tests on two species have been undertaken and are proceeding satisfactorily ; the work on one species being well advanced.

Preliminary tests of five species have been completed and reports have been issued on the results of the tests. Tests on five other species are in progress and on one the work is practically complete.

One special investigation has been completed and six other special tests are in progress. One trial on a commercial scale has been reported upon and two others are proceeding.

Collection of Information

The Committee's policy of collecting information in accordance with the scheme outlined in the report for 1931 and detailed in Paper No. E.T. 25[1], has been amply justified. The information collected was of considerable value in the preparation of statistics in connection with the Ottawa Conference.

[1] Development of Empire Timbers.—Summary Schedule of information to be assembled for each Empire country.

The Collection of Empire Timbers

From the surplus material in the collection, 616 small specimens have been sent to the Imperial Forestry Institute at Oxford, 519 similar specimens have been supplied to the City of London College and 495 to the Royal Botanic Gardens, Kew. Smaller consignments of specimens have been distributed under exchange arrangements or as presentations to educational and research institutions.

Report for the Ottawa Conference

A confidential report dealing with the work of the Empire Timbers Committee was prepared for the Empire Marketing Board for distribution to the delegates at the Ottawa Conference in July. The report commented upon the extent of the Empire markets for softwoods and hardwoods separately, drew attention to the preponderance of foreign supplies in those markets as well as to the possibilities of and requirements for extension of the markets for Empire timbers, and particularly emphasised the unique opportunity which now exists for such extension.

The work already completed was summarised in an appendix to the report. As no opportunity for securing consideration of this report occurred at Ottawa, it was redrafted for submission in London to the Imperial Committee on Economic Consultation and Co-operation in February, 1933.

2. Programme of Work

The Testing of Empire Timbers

During the year the Empire Timbers Committee considered and accepted the following applications :—

For major scale tests :

Mora	..	*Mora excelsa* Benth., from Trinidad
Ceylon gurjun	..	*Dipterocarpus zeylanicus* Thw., from Ceylon.

For limited major scale tests on the strength properties of :

Kapur.. ..	..	*Dryobalanops* spp.
Seraya merah	..	*Shorea* spp. and
Seraya puteh	..	*Parashorea* spp.

} from British North Borneo.

For preliminary investigations of the properties of :

Black Cabbage bark *Lonchocarpus Castilloi* Standl. from British Honduras.

For a special investigation on the kiln-seasoning properties of :

Silver Beech .. *Nothofagus Menziesii* Oerst., from New Zealand.

Applications for preliminary tests of the following were provisionally accepted :

Banak.. ..	..	*Virola merendonis* Pittier, from British Honduras.
Yemeri	..	*Vochysia hondurensis* Sprague, from British Honduras.
M'ninga	..	*Pterocarpus Bussei* Harms, from Tanganyika.

Details of the work which has been carried out in connection with the tests of various species during the year under review are given below :—

Major Tests

1. Munyama (*Khaya anthotheca* C.DC.) from Uganda.

The major scale tests of munyama are well advanced. The investigation of the mechanical, physical and seasoning properties of the green timber are now complete. Tests to determine to what extent the timber is suitable for veneering and the manufacture of high-grade plywood have been carried out, and sample ply-boards have been

prepared. Arrangements to supply, from the test consignment, selected seasoned material to be used in the construction of sample air-screws at the Royal Aircraft Establishment have been completed. Six other commercial trials have been arranged, and sample lots sent according to specification to various firms and railway companies.

The timber in the consignment was not as uniform in quality as might have been expected and the investigations now in progress may indicate, when complete, the desirability, if not the actual necessity, of carrying out some scheme of grading and selection prior to export. The Conservator of Forests in Uganda has recently been on leave in England and has visited the Laboratory on two occasions in connection with the tests.

2. Ceylon Gurjun (*Dipterocarpus zeylanicus* Thw.) from Ceylon.

Material for major tests of this species, amounting approximately to 2,350 cu. ft., arrived at the Laboratory at the beginning of November. The conversion of the logs was immediately taken in hand and tests are now in progress.

Commercial trials of the timber to determine its suitability for motor vehicle body-work, plywood for the manufacture of tea chests, and for flooring and building requirements are being arranged. It is proposed also to expose samples of the timber, after impregnation with creosote, to the action of sea-water, in order to discover whether it is suitable for use in this country for marine constructional work. It is also hoped to test the timber as decking for boats.

Limited Major Scale Tests

East African Camphor (*Ocotea usambarensis* Engl.) from Kenya.

It was expected that the material for these tests would arrive at the Laboratory during the summer. Owing to difficulties which arose in the Colony, the despatch was delayed. From information received in November, however, it is anticipated that the material will arrive early in 1933.

Preliminary Tests

1. Crabwood (*Carapa guianensis* Aubl.) from British Guiana.

The preliminary investigation of the properties of crabwood was completed and the report was issued in June, 1932. It was found, in the course of the investigation, that the timber kiln-seasoned slowly and that it was necessary to keep the temperature relatively low with a high humidity until drying had proceeded for some time, in order to prevent distortion and splitting. If the tendency to split could be overcome, its mechanical properties are such as to indicate its use for the manufacture of airscrews, and other purposes where strength is an essential property. The Director of Forest Products Research has, therefore, recommended that seasoning tests should be undertaken in British Guiana to determine whether it is possible to deal with this timber either by water seasoning or by green conversion, with a view to reducing the tendency to excessive splitting. A further comparative study of the structure of the hill-grown and swamp-grown crabwood has also been recommended. The tests indicate that, entirely apart from the manufacture of air-screws, selected material should be useful for cabinet work, shop-fittings and general hardwood joinery.

2. Greenheart (*Ocotea Rodioei* Mez) from British Guiana.

The results of the preliminary investigation on greenheart were reported upon in September, 1932. The timber was found to kiln-season extremely slowly and with considerable degrade when in thicknesses exceeding one inch. Thus, kiln-drying greenheart from the green state cannot be regarded as an economic proposition. The investigation of the mechanical properties indicated that the wood is extemely suitable for heavy contructional purposes.

It is proposed to carry out abrasion tests as soon as the new abrasion testing apparatus is complete, to determine whether the wood is suitable for flooring, more especially for use in warehouses where there is likely to be heavy wear on the floors.

3. Wallaba (*Eperua falcata* Aubl.) from British Guiana.

During the preliminary tests this timber was found to distort and to develop extensive splitting and " honeycomb " checking in the process of kiln-drying ; and it was shown to be very difficult to dry out the moisture from the centre. Gum was present in unusual quantities and exuded freely from all cut surfaces. Some of the timber received is being air-seasoned to ascertain how it behaves under this process. Until seasoning difficulties have been overcome there will be little or no prospect of finding a market for this timber.

Suggestions have been made by the Director of Forest Products Research that further experiments be carried out in British Guiana, which include :—

(*a*) green conversion followed by various methods of piling, and
(*b*) water-seasoning for three months prior to conversion.

If a satisfactory method of seasoning the timber is discovered, it may be advisable to carry out further tests.

4. Purpleheart (*Peltogyne ?pubescens* Benth.) from British Guiana.

The preliminary investigations of the properties of purpleheart were brought to a close in September, and a report on the results was issued. It was found that thin boards of this timber could be kiln-seasoned satisfactorily and fairly quickly. In greater thicknesses, however, there was some difficulty in drying the wood completely to the centre. Further research might lead to a solution of the problem of drying the timber in thicknesses greater than one inch.

The strength properties leave little to be desired, the wood being stiff and resistant to compression, whether applied parallel or perpendicular to the direction of the grain. It is not easy to work, especially in a very dry state, either with machine or hand tools, partly owing to the presence of gum in the wood. Nevertheless it turns readily. It changes colour fairly rapidly after conversion, especially when exposed to heat. Further tests have been recommended with the object of discovering methods of overcoming the difficulties met with in seasoning and working the timber.

5. Red Meranti (*Shorea leprosula* Miq.) from Malaya.

The preliminary tests of meranti tembaga were completed in April, 1932. The results tend to show that the timber is likely to season readily and satisfactorily. It appears to be sufficiently strong for all the purposes for which it is likely to be used. Its behaviour when worked with machine and hand tools is quite satisfactory. If proper

attention were paid to the conversion and grading before marketing it would probably be able to compete with Philippine red lauan.

6. Keruing (*Dipterocarpus cornutus* Dyer) from Malaya.

This timber was subjected to preliminary tests in the early part of the year, and the results of the investigation were reported upon in April. The timber was found to kiln-dry fairly rapidly, but some distortion, particularly in the form of "cupping," occurred during the process. It was found to be hard, and to compare favourably in strength properties with gurjun, which it resembles fairly closely in general appearance. The wood worked satisfactorily with machine and hand tools, but with a marked dulling effect on the cutting edges. It resembles Philippine apitong.

7. Santa Maria (*Calophyllum brasiliense* var. *Rekoi* Standl.) from British Honduras.

The preliminary tests of santa maria are now approaching completion and it is anticipated that a report will be ready for issue by the end of January, 1933. The timber has been subjected to veneer tests, but the sheets showed a tendency to split at the ends. Plywood built up of this, however, was of good appearance. This timber would appear to have distinct possibilities and the general results are sufficiently satisfactory to warrant the undertaking of major scale tests.

8. Black Cabbage Bark (*Lonchocarpus Castilloi* Standl.) from British Honduras.

The indentity of this species was formerly believed to be *Andira inermis* H.B. and K. Examination of the herbarium material, however, has proved it to be a new species which has received the name of *Lonchocarpus Castilloi* Standl. Two logs arrived at the Laboratory in November, and the allocation of the material to the various sections was immediatey undertaken. It is anticipated that the tests will be complete by the end of March, 1933.

9. Musisi (*Mæsopsis Eminii* Engl.) from Uganda.

The preliminary investigation of the properties of musisi is now proceeding. This and the following investigation were undertaken at the request of the Forest Department of Uganda, to determine whether the timbers are suitable for local use in place of softwoods imported from sources outside Uganda. The tests are now proceeding, but it is too early as yet to say whether these timbers may be substituted for softwoods with satisfaction to the users.

10. Mujua (*Alstonia congensis* Engl.) from Uganda.

Preliminary tests are proceeding satisfactorily. See note on the preceding species.

11. Coachwood (*Ceratopetalum apetalum* D. Don) from Australia.

The wood is reputed to be suitable for cabinet work and also to be tough and elastic. Preliminary tests were undertaken at the request of a firm of timber exporters in Australia with the object of establishing an export trade. The tests are proceeding normally and it is anticipated that a report will be prepared on the results of the tests early in 1933.

12. Ofun (*Mansonia altissima* A. Chev.) from Nigeria.

This species of timber was recommended for preliminary tests by the Director of Forests, Nigeria, to determine whether its properites were such as to permit of its use in this country in place of black walnut, *Juglans nigra* L.; supplies of which have, in the past, been largely obtained from the United States. The wood is of first-class appearance, and from the tests so far completed, it appears to season satisfactorily and to work easily. Information recently received indicates that the available supplies of this species in British West Africa are greater than was previously supposed. The investigation is nearing completion.

13. Podo (*Podocarpus* spp.) from Tanganyika Territory.

The exact identity of the two species of *Podocarpus*, which are to be submitted to preliminary tests for the Forest Department of Tanganyika Territory, is at present uncertain, but will be determined from the herbarium material which will accompany the timber for test. This is expected to arrive at the Laboratory in January or February, 1933.

14. Opepe (*Sarcocephalus Diderrichii* De Wild.). African Mahogany (*Khaya grandifoliola* C.DC.; *Khaya ivorensis* A. Chev.; *Khaya caudata* Stapf; *Khaya senegalensis* A. Juss.).

Arrangements for the supply of the material for the tests of the above species from British West Africa will be made by the officer who has been seconded to visit Nigeria and the Gold Coast Colony in order to establish closer contact with the regions of production.

15. African Walnut (*Lovoa Klaineana* Pierre ex Sprague) from Nigeria.

A further report on tests of the mechanical properties of air-seasoned material will be issued early in 1933.

Special Tests

1. Abura (*Mitragyna stipulosa* Kuntze) from Nigeria.

Since the publication of the 1931 report, Messrs. Lloyds Register of Shipping have concluded from the results of a collateral investigation that there are disadvantages in the practical use of wood linings in oil-carrying ships which overshadow the acid-resisting qualities of any particular species. In these circumstances it was sought to determine whether abura might find application as a constructional material for acid-containing vats but investigation has shown that while the wood may be worthy of trial for this purpose certain economic difficulties will have to be overcome before it can compete with other vat woods for which there appears to be an established market. In this connection it should not be overlooked that the total estimated annual value of vats and other wooden vessels manufactured for storage in this country is of the order of £50,000[1]. and that in many cases wood is being replaced by acid-resistant steels and other alloys. Furthermore, in view of the introduction of rubber and other linings for chemical vats it is anticipated that the choice of woods for this particular purpose may not be as limited as it has been in the past.

Two commercial firms have tested the suitability of abura for manufacture into battery separators but the preliminary reports are not encouraging. Apparently the machining qualities of the consignments under test were not entirely satisfactory and the finished separators were decidedly weakened by the chemical treatment considered necessary prior to their use in batteries. Before proceeding further with chemical investigations in connection with this timber it is proposed to await the report of an officer of the Laboratory who is at present in Nigeria for the purpose of studying at first-hand the economic possibilities of a number of local woods including abura.

(1) Fourth Census of Production, 1930. *Board of Trade Journal*, 1932, Vol. 129.

2. East African Pencil Cedar (*Juniperus procera* Hochst.) from Kenya.

As mentioned in the 1931 report, the difficulty of softening this timber for pencil manufacture can be overcome. The softening process worked out at the Laboratory involves treatment of the wood with saturated steam under moderate pressure and subsequent impregnation with a dilute emulsion of an oil of low saponification value. A series of experiments has been carried out in co-operation with a well-known firm of pencil manufacturers and the results indicate that the treatment definitely renders the wood more easy to whittle although so far there is little indication that it eradicates the tendency to warp inherent in certain samples. Despite the growing conviction that the elimination of warping in the finished product may best be secured by stricter grading of the raw material this aspect of the problem is still receiving the close attention of the Section of Seasoning.

3. Turpentine (*Syncarpia laurifolia* Tenore) from Australia.

Tests of the mechanical properties of turpentine are well advanced. These were undertaken at the request of the Falmouth Docks and Engineering Company to obtain strength statistics upon which specifications for marine constructional work could be based.

4. Mora (*Mora excelsa* Benth.) from Trinidad.

In connection with the investigation to determine whether mora can be impregnated satisfactorily with creosote, a further consignment of 58 sleepers was received from Trinidad at the end of October. The Conservator of Forests originally intended to ship 120 sleepers, but material from the south of the island only could be procured, and this fact, together with the financial stringency, led to the number being reduced by approximately one half. When the treatment has been completed 50 sleepers will be returned to Trinidad for actual service trials.

5. Western Hemlock (*Tsuga heterophylla* Sarg.) from British Columbia.

Tests of the working qualities of western hemlock have been completed. The timber is now undergoing durability tests in the Mycological laboratory; it is unlikely that these will be completed before the end of June, 1933.

6. Western Red Cedar (*Thuja plicata* D. Don) from British Columbia.

Durability tests of this species are in progress. They are unlikely to be completed before June, 1933.

7. Queensland Walnut (*Endiandra Palmerstonii* C. T. White) from Australia.

Work on this timber has been postponed pending the completion of the research now in progress in Australia.

8. Blackbean (*Castanospermum australe* A. Cunn.) from Australia.

It has not yet been possible to secure a supply of air-dry material for the investigation of collapse in this timber.

9. Teak (*Tectona grandis* L.f.). Mvule (*Chlorophora excelsa* Benth. and Hook. f.). Borneo Whitewood (*Parashorea ?plicata* Brand.).

The minor scale investigation of the comparative properties of the above species for the Director of Dockyards was completed and a brief report was issued in March, 1932.

10. Silver Beech (*Nothofagus Menziesii* Oerst.) from New Zealand.

The New Zealand Government submitted a request that a consignment of silver beech should be inspected on arrival and subsequently subjected to an investigation of its kiln-seasoning properties. The work is now in progress and it is hoped that a report will be issued early in 1933.

Commercial Tests

1. Indian-grown Honduras Mahogany (*Swietenia macrophylla* King).

The commercial tests on the Indian-grown Honduras mahogany received in July, 1931, were completed and a report embodying the results was issued in July, 1932. The investigations indicated that the timber is very similar in quality to that grown in Honduras and that therefore the growing of this species in India appears to offer commercial possibilities.

2. Silver Beech (*Nothofagus Menziesii* Oerst.) from New Zealand.

The commercial tests of this species are not yet complete.

3. Tawa (*Beilschmiedia Tawa* T. Kirk) from New Zealand.

Commercial tests of this timber are under consideration pending information regarding supplies.

Practical Trials of Empire Timbers

Trials of flooring material of Empire timbers at the Laboratory are being continued. A floor of Indian gurjun has been laid on the landing at the top of the main staircase in the Administration block at the Laboratory. This was presented by Messrs. Hollis Bros. & Co., Ltd., who not only supplied the material, but sent their own workmen to lay it.

Courses of Study for Research, Utilization and other Officers.

During the year twenty students undertook courses of training at the Laboratory Four Forest Officers, from Nigeria, Gold Coast Colony, Federated Malay States and British Guiana respectively, were seconded to undergo training in Utilization in accordance with a scheme approved by the Secretary of State for the Colonies. Three other Forest Officers from Kenya, Burma, and Nigeria, three Officers from the Indian Ordnance Department, four scientific students and six others from private firms were undergoing instruction during the year.

The total number of officers of Forest Services and other government departments who have taken courses at the Laboratory is now thirty-five.

R. S. PEARSON,
Director.

May, 1933.

APPENDIX I

LIST OF SCIENTIFIC AND TECHNICAL STAFF

Director of Forest Products Research : R. S. Pearson, C.I.E., F.L.S.
Assistant Director : F. M. Oliphant.
Senior Technical Assistant : H. A. Cox, M.A., Dip. For., Dip. Tim. Tech.
Administration Officer : A. R. H. Cox.
Scientific Field Assistant : A. N. David.
Publications and Records Officer : W. H. Lovegrove.
Technical Assistant (Photographer) : W. R. Hutchins.

Section of Wood Structure

Officer in Charge : B. J. Rendle, B.Sc., A.R.C.S.
Assistant, Second Class : S. H. Clarke, M.Sc.
Junior Assistant : E. W. J. Phillips, B.Sc., A.R.C.S.

Section of Timber Physics

Officer in Charge : W. W. Barkas, M.Sc.
Assistant, Second Class : E. D. van Rest, B.A., B.Sc.

Section of Seasoning

Officer in Charge : S. T. C. Stillwell, B.Sc.
Assistant, Second Class : R. G. Bateson, B.A.
Junior Assistants : R. A. G. Knight, B.Sc. (Eng.) ; W. C. Stevens, M.A.
Junior Technical Assistants : L. S. Doman ; R. E. Hodge ; G. H. Pratt ; D. D. Johnston ; R. J. Newall ; N. Turner.

Section of Timber Mechanics

Officer in Charge : C. J. Chaplin, M.Sc., M.E.I.C., M.I.Mech.E.
Assistants, Second Class : J. Latham, B.Sc. ; F. H. Armstrong, M.Sc., A.M.I.Mech.E. ; Miss C. B. Pettifor, B.Sc.
Junior Assistants : T. Hamilton, B.Sc., A.M.I.E.S. ; E. H. Nevard, B.Sc.
Technical Assistants : Miss I. M. Elliot, B.Sc. ; A. J. Foord.

Section of Wood Preservation

Officer in Charge : J. Bryan, M.Eng., A.M.Inst.C.E.
Junior Assistant : N. A. Richardson, B.Sc., A.I.C.
Junior Technical Assistant : D. N. Smith.

Section of Mycology

Officer in Charge : K. St. G. Cartwright, M.A., D.I.C., F.L.S.
Assistant, Second Class : W. P. K. Findlay, M.Sc., A.R.C.S., D.I.C.
Junior Technical Assistant : E. C. Badcock.

Section of Entomology

Officer in Charge : R. C. Fisher, B.Sc., Ph.D.
Assistant, Second Class : F. R. Cann, D.I.C.
Junior Assistant : E. A. Parkin, B.Sc., D.I.C.
Junior Technical Assistant : E. C. Harris.

Section of Wood Chemistry

Officer in Charge : W. G. Campbell, B.Sc., M.S.
Assistant, First Class : Miss M. H. O'Dwyer, B.Sc., Ph.D., D.I.C.
Junior Assistants : J. Booth, B.Sc., Ph.D., A.I.C. ; Miss K. F. Taylor, B.Sc., Ph.D., A.I.C.

Section of Utilization

Officer in Charge : J. R. Cosgrove, D.S.O., M.C., M.E.I.C.
Assistant, First Class : P. Harris, B.Sc.
Senior Technical Assistant : J. C. Thirlwell.
Assistant : H. E. Kinns.
Technical Assistant : Miss D. M. Wells, B.Sc.

APPENDIX II

LIST OF PUBLICATIONS

A.—*Stationery Office Publications**

	Price s.	Price d.
Report of the Forest Products Research Board for the period ended 30th September, 1928 .. .. (1929)	3	0
Report of the Forest Products Research Board for the period ended 31st December, 1929 (1930)	4	0
Report of the Forest Products Research Board for the year 1930	4	0
Report of the Forest Products Research Board for the year 1931	3	6
TECHNICAL PAPERS :—		
No. 1.—The Movement of Moisture with reference to Timber Seasoning. By S. T. C. Stillwell, B.Sc. .. .. (*Out of print*)		
No. 2.—Moisture Movement through Wood. The Steady State. By J. F. Martley, D.I.C., B.Sc. .. .. (1926)	1	3
SPECIAL REPORTS :—		
No. 1.—The Air-Seasoning and Conditioning of Timber. By F. M. Oliphant .. (1927)	2	0
No. 2.—The Principles of Kiln-Seasoning of Timber. Part I.—Types of Commercial Kilns in Use. By S. T. C. Stillwell, B.Sc. .. .. (1928)	0	9
BULLETINS :—		
No. 1.—Dry Rot in Wood .. .. *Revised edition* (1933)	1	0
No. 2.—*Lyctus* Powder-Post Beetles. By Ronald C. Fisher, B.Sc., Ph.D. .. (1929)	3	0
No. 3.—British Hardwoods. Their Structure and Identification. By L. Chalk, M.A., and B. J. Rendle, B.Sc. .. .. (1929)	5	0
No. 4.—Decay of Sitka Spruce Timber caused by *Trametes serialis* Fr. By K. St. G. Cartwright, B.A. .. .. (1930)	2	0
No. 5.—The Moisture Content of Wood with reference to Furniture Manufacture. By S. T. C. Stillwell, B.Sc. .. .. (1930)	2	0
No. 6.—The Timber of Corsican Pine (*Pinus Laricio* Poiret) .. .. .. (1930)	2	6
No. 7.—Home-Grown Timbers. Their Anatomical Structure and its Relation to Physical Properties. Elm. By S. H. Clarke, B.Sc. .. .. .. (1930)	3	6
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